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CONTRIBUTIONS

TO

CANADIAN PALÆONTOLOGY

VOLUME III (Quarto).

PART V.—PALÆONISCID FISHES FROM THE ALBERT SHALES OF NEW BRUNSWICK.

BY

LAWRENCE M. LAMBE,

Vertebrate Palæontologist.

OTTAWA
GOVERNMENT PRINTING BUREAU
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LETTER OF TRANSMITTAL.

To R. W. Brock, Esq.,
Director Geological Survey,
Department of Mines.

Sir,—

I beg to submit the following memoir on the "Palæoniscid Fishes from the Albert Shales of New Brunswick," which forms Part V of Volume III (quarto) of Contributions to Canadian Palæontology.

I have the honour to be, Sir,
Your obedient servant,

(Signed) LAWRENCE M. LAMBE.

Ottawa, May 14, 1909.

UNIVERSITY OF WISCONSIN
DEPARTMENT OF GEOLOGY

INTRODUCTORY.

The bituminous shales of Albert county, New Brunswick, apart from their commercial value, have long been noted for their well preserved remains of fishes belonging to the family Palæoniscidæ. Since the publication, in 1851, of Dr. Charles T. Jackson's descriptions of Albert mine fishes, this particular fauna has not received the attention that it deserves. A thorough knowledge of the character and structure of the various species represented is of importance, as an aid in the determination of geological horizons in New Brunswick and Nova Scotia.

In the following pages will be found the results of a study, by Mr. Lawrence M. Lambe, of the Albert shales fish fauna, based on the large collections of specimens from the typical locality and its neighbourhood, in the possession of the Geological Survey, and on type material and well preserved specimens from the same localities kindly loaned by the Museum of Comparative Zoölogy, Cambridge, Mass.; the Boston Society of Natural History; McGill University; and the Natural History Society of New Brunswick.

Mr. Lambe's memoir forms part V of volume III (quarto) of 38 pages of text with eleven full-sized photogravure plates.

(Signed) R. W. BROCK,
Director.

Geological Survey,
Department of Mines,
Ottawa.

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PALÆONISCID FISHES

FROM THE

ALBERT SHALES OF NEW BRUNSWICK

BY

LAWRENCE M. LAMBE

Vertebrate Palæontologist.

INTRODUCTION.

ALBERT SHALES—AREA—GENERAL CHARACTER—MODE OF OCCURRENCE, ETC.

The highly bituminous, calcareous shales of New Brunswick, as developed in Albert and Westmorland counties, and known as the Albert shales, can be traced from about two miles west of Elgin Corner, across Albert county in a northeasterly direction, to the Memramcook river, at Taylorville, in Westmorland county, a distance of a little over thirty miles. Throughout this distance they are not continuously exposed, and in Albert county their breadth is seldom seen to exceed half a mile; in Westmorland county their exposed breadth is greater. Slight changes in the physical characters of the beds are found at different localities, and sandy layers and dolomitic-looking limestone are occasionally introduced as thin bands. The shales and sandy layers are bituminous throughout, in a varying degree according to locality.

Associated with the Albert shales, and lying conformably beneath them, are greenish-grey conglomerates, the whole having an estimated thickness of about 1,000 feet. The shales are of a dark grey and brown colour, and are sometimes much disturbed, being in places faulted and inclined at high angles. They are generally overlaid unconformably by massive beds of dark coloured conglomerate, associated with sandstone.

At Albert Mines and vicinity, certain layers of the shales are replete with the remains of fishes of the family Palæoniscidæ. These fish-bearing beds consist for the most part of brown to dark grey shales, of which the brown generally split very readily into thin sheets, and brownish black oil bands, attaining a thickness sometimes of 5 or 6 feet. These latter, on account of their richness in oil and sulphate of ammonia, are attracting considerable attention at the present time, commercially. In this connexion the reader is referred to the report of Dr. R. W. Ells (21), lately published, on the oil-shale industry of Scotland, where similar beds occur, and the very favourable conditions existing in New Brunswick and Nova Scotia for the establishment of a like

industry in eastern Canada. Dr. Ells expresses the opinion, "that in general character and value, the shales of New Brunswick—both as regards the products of crude oil and sulphate of ammonia obtained therefrom—compare favourably, and in some cases undoubtedly surpass those distilled in Scotland."

The majority of the fish-remains in the Albert mines area come from the thinly splitting brown and grey shales; but excellently preserved specimens also occur in the thicker and darker layers, and some have been found in nodules.

Mr. R. D. Stewart (19) in "The Chemistry of the Oil-Shales," part III of the memoir of the Geological Survey (Scotland), enters fully into the probable origin of kerogen, the term that has been applied to the carbonaceous matter in shale that gives rise to crude oil in distillation.

He points out that the carbonaceous matter, with clay, was probably deposited at the bottom of lagoons; and that vegetable matter, such as, for instance, pine-pollen, or lycopod-spores, or animal matter such as might be derived from entomostraca (of which some shales are largely made up), or, in fact, any kind of organic matter, may, through the action of microbes, have been converted into kerogen.

His conclusion is that "oil-shale may be composed of (1) vegetable matter which has been made into a pulp by maceration in water and preserved by combining with the salts in solution; (2) richer materials of many kinds, such as spores, which nature has provided with means for some protection against decay; and (3) a proportion of animal matter."

It is probable that the waters in which lived the fishes about to be described, were cut off to a great extent from the sea, and formed the lagoons in which the material that produced the shales was deposited.

The numberless remains of fishes in some of the beds can be attributed only to the occasional wholesale destruction of the fishes.

Any sudden or material change in the condition under which the fishes existed would result in loss of life. Such unfavourable conditions might be caused by the resumption of free communication between the lagoons and the open sea, or the lagoons may have felt the influence of drought, and have, at times, almost disappeared.

The appearance of the fishes in their fossilized state suggests differences in the conditions affecting them after death and prior to entombment in the vegetable mud forming the bottom.

The appearance of some seems to indicate that decomposition, to a greater or less extent, took place in the water, while others seem to have been desiccated prior to their entombment. Decomposition would result in an increase in the depth of the body, and, according to the lapse of time, a later partial or complete disintegration with a more or less scattered disposition of the remains; the majority of the fishes from the Albert shales have a disproportionate depth, although some are evidently but little distorted and give a nearly true outline of the body. The latter were probably soon enclosed in the muddy bottom, and thus escaped the action of

the air and water, before they had become much decomposed. Some specimens are long in proportion to their depth, and have every appearance of shrinkage and contraction, as if the fish had been thoroughly dried under a hot sun.

These differences in proportion are most noticeable in the large specimens (*Elonichthys browni*) from the Albert mines.

In most cases degrees of distortion, due to pressure during fossilization, supplement the earlier disfigurements.

Previous Work.

In the Report of Progress for 1876–77, Geological Survey of Canada, 1878, the distribution and geological age of the Albert shales are discussed at length by Professor L. W. Bailey, and Dr. R. W. Ells, in their joint "Report on the lower Carboniferous belt of Albert and Westmorland counties, N.B., including the Albert Shales." The general conclusion reached at that time, as to the geological age of the shales, was that they occupied an almost basal position in the lower Carboniferous formation, the lowest member being a conglomerate, of, at that time, unknown thickness. The presence of fossil fishes belonging to the Palæoniscidæ was relied on, in great measure, as an index to the age of these beds. Comment is made on the abundance of fishes, in marked contrast to the paucity of the plant remains, which were, however, considered to be referable to typical lower Carboniferous species (p. 357).

In 1880, an opinion was expressed by Professor Bailey and Drs. G. F. Matthew and R. W. Ells, in their "Report on the Geology of Southern New Brunswick, etc." (Geological Survey of Canada, Report of Progress for 1878–79) p. 16 D, that "Stratigraphically, the beds of Albert shales, as developed in Albert and Westmorland counties, may belong to a lower horizon than the Carboniferous, and may constitute an upper portion of the Devonian, but the prevailing fossils, both fishes and plants, seem to indicate a lower Carboniferous age."

At a later date in his "Report on the Geological Formations of Eastern Albert and Westmorland counties in New Brunswick, etc.," (Vol. I, New Series, 1885), Dr. Ells retained the Albert shales in his divisions of the lower Carboniferous, recognized in New Brunswick next above a basal conglomerate, presumably about 200 feet in thickness (p. 33 E.) A general section of the lower Carboniferous rocks in this area is given, in ascending order, in this report as follows:—

(1.)	Basal conglomerate, sometimes wanting; when present, usually of a dull greenish colour, made up mostly of slate fragments; thickness, presumably about....	200 ft.
(2.)	Calcareo-bituminous shales, from grey to dark brown in colour, including the so-called Albert shales.....	850 "
(3.)	Grey bituminous and micaceous oil-bearing sandstone, and lower conglomerates, in massive beds, usually of reddish tint, less rubbly and more calcareous than those of No. I, and unconformable to the preceding.....	700 "
(4.)	Red and grey calcareous, sandy, and argillaceous beds, in frequent alternations, with thin beds of conglomerate, and, towards the top, heavy beds of fine rubbly brownish-red shales.....	450 "
(5.)	Red and grey conglomerates, grey and flaggy limestones and gypsum	1,950 "

The above reports are the principal ones of the Geological Survey in which the age of the Albert shales is discussed, prior to the publication, in 1903, of Dr. Ells' report on "The Albert Shale Deposits of Albert and Westmorland Counties, N.B." (Summary Report of the Geological Survey Department for 1902,) in which the shales in question are definitely assigned to the upper Devonian (p. 361). Dr. Ells writes as follows: "As to the geological position of the shales as a whole it may be remarked that somewhat diverse opinions have been held from time to time by different observers. Thus in the early days of their investigations it was supposed that they represented an integral portion of the lower Carboniferous formation. This conclusion was reached from the presence in certain bands of the shale of remains of fossil fishes and plants which were supposed to have a lower Carboniferous aspect and to definitely fix their horizon. The investigations made in 1876 showed that however true this might be, the mass of the shales themselves occupied a position entirely unconformable to the true lower Carboniferous sediments, associated with limestones and gypsum, and which are well defined throughout the area, and that with good reason they should, therefore, stratigraphically be assigned to a lower horizon, or regarded as of Devonian age."

In 1871, Sir J. William Dawson (6), in commenting on the great value of palæontology to the "practical man and theoretical geologist," remarked with truth that "A simple characteristic fossil is often sufficient to determine the geological age of a formation, and the question of geological age is one that must be ascertained previous to any deductions whether as to the mineral contents or conditions of formation of strata." These remarks preceded reference to "the disputes as to the Devonian or Carboniferous age of the celebrated deposit of Albertite at Hillsborough, New Brunswick." These and similar difficulties, Sir William adds, could have been readily settled by a reference to the evidence of fossil plants.

Since these observations were made it has been generally conceded that the remains of vertebrate animals can be relied on to a greater extent than those of plants, and of members of the other divisions of the animal kingdom, as more exact horizon markers, since vertebrates are more susceptible to change in the process of evolution.

The Albert shale series and its equivalents, named by Dawson "The Lower Carboniferous Coal Measures or Lower Coal Measures," and forming his fifth or lowest division of the Carboniferous system (10,1891), in eastern Canada, are described by him as "holding some, but not all, of the fossils of the Middle Coal formation, and thin coals, not productive; but differing both in flora and fauna from the upper Devonian, which they overlie unconformably." * * * "In some localities these resemble in mineral character the true coal measures. In others they present a great thickness of peculiar bituminous and calcareous shales. They usually contain in their lower part thick beds of conglomerate and coarse sandstone, which in some places prevail to the exclusion of the finer beds. The characteristic plants of these beds are *Lepidodendron corrugatum* and *Cyclopteris Acadica*, with *Dadoxylon antiquius*, and *Alethopteris heterophylla*. They also contain locally great quantities of remains of fishes, and many Entomostracans, among which are *Leaia Leidyi* and an *Estheria*, also *Leperditia subrecta*, Portlock, *Beyrichia colliculus*, Eichw., and a *Cythere*, probably new." "This formation is not everywhere distinguishable at the base of the Carboniferous, and is variable in its characters. It is seen in southern Cape

Breton, in the county of Sydney, and in Hants; but its most remarkable and interesting exposures are at Horton bluff and at Hillsborough, and other places in southern New Brunswick. In the last-mentioned locality, it affords the remarkable bituminous mineral known as Albertite."

Field work of 1908 and general conclusion regarding age.

During the summer of 1908, the writer, on behalf of the Geological Survey, visited the Albert shales area (22), spending some weeks at the Albert mines, where a large collection of fish remains was obtained, principally from beds of readily splitting brown shales exposed on the western branch of Frederick brook, in an exposure from which two collections, lately received by the Geological Survey, had been made. By searching the dump, a number of specimens, brought from a low level, were also found. To the southwest of the Albert mines, an examination of the beds was also made at Rosedale, Baltimore, Turtle Creek, Mapleton, and Elgin Corner, as well as at exposures seen in brooks and near the road. Continuing the examination of the shale area to the northeast, some time was spent at Taylorville, on the Memramcook river, within reach of Beliveau by road, at both of which places there are exposures of shale. At Taylorville there is a low cliff for some distance along the river front, constituting an excellent exposure of the Albert shales, from which, however, only plant remains were obtained.

The shales of the Albert mines and Beliveau are similar in character, and have a flora and fish fauna common to both, the Beliveau area, between the Petitcodiac and Memramcook rivers, being a continuation to the northwest of the Albert mines area. All the species of fishes that have been found so far at Beliveau are included in the Albert mines fauna. There is a great similarity between the fishes of the Albert mine and Beliveau areas, and those described by Dr. Ramsay H. Traquair from the Calciferous Sandstone series of Scotland; they belong to the same genera, but differ as to species.

The genera of Palæoniscidæ, *Rhadinichthys*, *Elonichthys*, and *Canobius*, so abundantly represented in the New Brunswick and Scottish shales, have been considered to be typical of the Carboniferous age. *Cheirolepis canadensis*, Whiteaves, from the upper Devonian of Scaumenac bay, Quebec, is an early member of the family, and the only completely preserved representative of the Palæoniscidæ known from the Devonian of North America. The species of *Rhadinichthys* described from the Carboniferous rocks of England, Scotland, and the United States, with *R. alberti* from New Brunswick, include the known species of the genus, with the exception of three from the upper Devonian of New York state, described from fragmentary remains, with doubtful generic reference, under the names *Palæoniscus antiquus*, Williams, *P. reticulatus*, Williams (both from the Portage beds near Buffalo, New York), and *P. devonicus*, Clarke, (Naples beds of Sparta, New York). These three species are thought by Eastman to be properly referable to *Rhadinichthys*. Also, Eastman has lately described (20) a species, *R. deani*, from the base of the Waverley series in Kentucky, and another of the same genus, not specifically named, from the Chemung of Warren, Pennsylvania. The remains on which *R. deani* is based were obtained from phosphatic nodules, and, although fragmentary, are remarkable for the preservation of the soft tissues of the head. It is probable that the discovery of less fragmentary remains will prove these Devonian species to be generically distinct from the Scottish Carboniferous species on which Traquair founded his genus *Rhadinichthys*.

In 1908, additional palæontological evidence was obtained, at Horton bluff, Kings county, N.S., of the Carboniferous age of the beds at this place, exposed in cliffs on the shore of Avon river. These beds were placed by Dawson, on the evidence of their fossils, in the lower Carboniferous, at about the horizon of the Albert shales. Separate teeth and a clavicle (22) were found of a species of *Strepsodus* probably referable to *Strepsodus hardingi* (Dawson), originally described from Horton bluff. Species of *Strepsodus*, and of the closely allied genus *Rhizodus*, are known from the Calciferous Sandstone series of Scotland; both genera are typically Carboniferous in Great Britain and North America and apparently do not occur in the Devonian.

All the Palæoniscidæ found in the Albert shales of New Brunswick belong to the same genera as, although differing specifically from those of the Carboniferous Sandstone series of Mid and West Lothian, and other localities in Scotland.

This series of rocks is considered, by the geologists of the British Survey, and others who have made a special study of the oil-shale fields in Scotland, to form the base of the Carboniferous system in that country. According to them the Carboniferous sandstones are the downward continuation of their Carboniferous Limestone series, and rest conformably on the upper Old Red Sandstone. The Calciferous Sandstone series includes fish-bearing shales, which are almost identical in composition and physical characters with the Albert shales.

The great similarity of the fish fauna of the shales in the two countries can lead to no other conclusion than that they are synchronous deposits.

It is believed, therefore, that the age ascribed to these fish-bearing shales in Scotland should also be ascribed, on the evidence of their fossils, to the Albert shales of New Brunswick, and that the strata in the two countries are geological equivalents.

With the foregoing introductory remarks relative to the Albert shales of Albert and Westmorland counties of New Brunswick, the mode of their occurrence and their probable age, we may pass on to a short reference to Dr. Charles T. Jackson's work on this particular fauna, and of that of a number of distinguished palæontologists in later years. Preceding the descriptions of the species of Palæoniscid fishes so well and abundantly preserved in these rocks is a statement of the material on which the descriptive portion of this report is based.

Earlier Descriptions of, and references to Albert Shale Fishes.

In the year 1851, Dr. Charles T. Jackson described a number of Palæoniscid fishes, obtained by himself and others, from the shales at Hillsborough, Albert county, New Brunswick. The results of his study of these fish remains appeared in his "Report on the Albert Coal Mine (Boston, 1851), pp. 22–25," and in a paper entitled "Descriptions of five new species of Fossil Fishes" in the Proceedings of the Boston Society of Natural History, vol. iv, 1851, pp. 138–142. At this time Dr. Jackson described and named three species, *Palæoniscus alberti*, *P. brownii*, and *P. cairnsii*, and gave descriptions of a number of specimens without specific references. In the first named paper reference is made to two plates of illustrations, which, however, were not published.[1] In the second the descriptions are without figures. Lately the original drawings

[1]It is probable, judging from the references made by Egerton, Dawson, Traquair, and others, to drawings of Jackson's types, that a few copies, at least, of the plates intended for the illustration of the 1851 paper and report on the Albert mine fishes were later distributed to leading interested palæontologists in North America and Europe.

of these unpublished plates have been brought to light in the Yale Museum, New Haven, by Dr. Charles R. Eastman of Cambridge, Mass. Through this fortunate find Dr. Eastman has been able to identify most of Jackson's types and figured specimens from among the material from the above locality in the collections of the Museum of Comparative Zoology, Cambridge, and of the Boston Society of Natural History.

In the Quarterly Journal of the Geological Society of London, vol. ix, 1853, p. 115, Sir Philip Grey Egerton, Bart., under the heading, "Note on the Fossil Fish from Albert Mine," briefly remarks on the fossil fishes from this mine in Sir Charles Lyell's collection, and the museum of the Geological Society. The opinion is expressed that they belong to the genus Palæoniscus, and certain specimens are identified with Jackson's species. Sir Philip adds that "all the species from this locality are remarkable for the remote position of the dorsal fin, and the highly sculptured ornamentation of the headbones and scales. They are also remarkable for the large size of the scales covering the dorsal angle. Some of the larger specimens figured by Dr. Jackson, especially fig. 2, pl. 1, have great resemblance to the forms of *Palæoniscus*, graduating into the characters of *Eurynotus* and *Amblypterus*, found at Burdie House and Newhaven, in Scotland. They are all quite remote in character from the *Palæonisci* of the Kupfer Schiefer and magnesian limestone." In the same number of this Journal, on p. 110, in a paper "On the Albert Mine, Hillsborough, New Brunswick," Sir J. William Dawson refers to the abundant and beautifully preserved remains of fishes in the Albert shales, mostly belonging to the genus Palæoniscus.

In 1868, in the second edition of "Acadian Geology," p. 231, Sir J. William Dawson again refers to these fossil fishes, and gives a figure, in the text, of *Palæoniscus alberti* (?) Jackson.

In the Canadian Naturalist, 2nd series, vol. VIII, 1877, in his article entitled, " Carboniferous fishes of New Brunswick," pp. 337–340, Dawson adds two species to the fish fauna of these shales, viz., *Palæoniscus* (*Rhadinichthys*) *modulus* and *P. jacksonii*, and supplies further notes on the original species *P. alberti*, *P. cairnsi*, and *P. browni*, from information gained from additional specimens. A restored outline is given of *P. modulus*, with figures of the scales (figs. 18*a*, *b*, *c*, *d*, p. 338). This paper also appears in the same year, without change, as part of the supplement to the second edition of Acadian Geology.

Dr. Ramsay H. Traquair had in 1877 (Quart. Jour. Geol. Soc. of London), in his paper "On the *Agassizian genera* Amblypterus, Palæoniscus, Gyrolepis, and Pygopterus," expressed the opinion that "*Palæoniscus alberti*, Jackson, and more especially *P. cairnsi* * * * and some of the other small Palæoniscidæ from the Coal Measures of New Brunswick," seemed to be allied to *Rhadinichthys carinatus* (Ag.).

In Dr. John Strong Newberry's monograph on "The Palæozoic Fishes of North America," (15) p. 187, is to be found an enumeration of the then known species from the "Lower Carboniferous rocks of New Brunswick." These species, which Dr. Newberry remarks are to be assigned partly to the genus *Rhadinichthys* and partly to *Elonichthys*, are *Palæoniscus alberti*, Jackson; *P. cairnsii*, Jackson; *P. brownii*, Jackson; *P. jacksonii*, Dawson; and *P. modulus*, Dawson.

In 1891, in part II of the "Catalogue of the Fossil Fishes in the British Museum," Dr. Arthur Smith Woodward supplied brief descriptions of three of these species, under the names *Rhadinichthys alberti*, (Jackson), *R. cairnsi* (Jackson), and *R. modulus* (Dawson). *Elonichthys browni* (p. 501) is mentioned under doubtful and imperfectly defined species.

Lately Dr. Charles R. Eastman, in his Devonian Fishes of Iowa (Iowa Geological Survey, volume XVIII, 1908), has included references to *Rhadinichthys alberti*, *R. cairnsi*, and *R. modulus*, specifying these species as from the lower Carboniferous of Albert county, N.B.

The foregoing are the principal references to the fishes from the Albert shales since the original descriptions appeared in 1851, a period of nearly sixty years. Jackson's plates of figures, although a few copies may have been distributed, were not available to most palæontologists. The fortunate discovery by Dr. Eastman of Jackson's original drawings has made possible the recognition of the types and figured specimens.

Collections—Acknowledgments—Type material loaned.

The Geological Survey of Canada received, in the autumn of 1907, two large collections of fishes from the Albert shales of New Brunswick, one made by Dr. R. W. Ells, of this Survey, the other by Mr. James Robertson, of the Albert mines.

With a view to reporting on the Albert shales fish fauna generally, the writer, in January, 1908, turned his attention to these collections, and to the material from the typical locality and vicinity already in the museum of the Geological Survey, collected principally by Dr. R. W. Ells in 1876, by Dr. F. D. Adams in 1877, and by Mr. James Robertson in 1891. There is also now available for study the large collection made at the same locality by the writer, during the summer of 1908.

My thanks are respectfully tendered to Dr. Frank D. Adams of McGill University, to Dr. Charles R. Eastman and Mr. Samuel Henshaw of the Museum of Comparative Zoology, Cambridge, Massachusetts, to Mr. Charles W. Johnson of the Boston Society of Natural History, and to Dr. G. F. Matthew, St. John, N. B.; to Dr. Adams for affording me the opportunity of examining the type specimen of Dawson's *Palæoniscus* (*Rhadinichthys*) *modulus* and other specimens of Albert shales fishes from New Brunswick, the property of the Peter Redpath Museum, Montreal; to Dr. Eastman and Mr. Henshaw, for the loan of Jackson's type, and figured specimens that belong to the Museum of Comparative Zoology, and also for the much appreciated gift of photographs of Jackson's original drawings for his two plates; to Mr. Johnson for the loan of Albert Mines fish material, the property of the Boston Society of Natural History, in which are included the originals of three of Jackson's figures; and to Dr. Matthew for having kindly placed in my hands a number of specimens, from the Albert mines, belonging to the Natural History Society of New Brunswick.

The specimens received from the Museum of Comparative Zoology are the originals of Jackson's figures, as follows:—

Plate I, figure 1. Type of *Palæoniscus alberti*, Jackson, No. 7899; 1960.
Plate I, figure 2. Type of *Palæoniscus brownii*, Jackson, No. 7900; 1961.
Plate I, figure 3. Type of *Palæoniscus cairnsii*, Jackson, No. 7899*a*; 1956.
Plate I, figure 5. Not described by Jackson. No. 7901; 1957.
Plate II, figure 2. *Palæoniscus* sp. of Jackson, No. 7987; 1959.
Plate II, figure 3. *Palæoniscus* sp. of Jackson, No. 7987*a*; 1958.
Plate II, figure 7. Lower jaw of *Palæoniscus*. No. 7903; 1953.

Included with the specimens lent by Mr. Johnson are the following specimens figured by Jackson:—

Plate II, figure 1, *Palæoniscus* sp. of Jackson. No. 7902.
Plate II, figure 5. Not described by Jackson. No. 7898.
Plate II, figure 8. Not described by Jackson. No. 7898*a*.

It may be mentioned here, that, in that part of Dr. Jackson's report on the Albert coal mine having special reference to the fossil fishes, there are certain discrepancies in the numbers denoting the figures of the plates: thus "Figures 3 and 3 bis" (p. 21) should read *Figures 2 and 2 bis*, the same specimen being referred to at the bottom of page 23 (Fig. 2, 2 bis) and shown in figures 2 and 2 bis of Plate II. Also "Figure 4" (p. 21) and "Fig. 3" (p. 24) both refer to fig. 3 of Plate II. Again, "Fig. 8" (p. 24) should properly read *figure 6*, as fig. 6 of Plate II illustrates the specimen described.

From a study of the type material, and specimens, lent to me, and of the collections belonging to this Survey, there appear to be five species of Palæoniscid fishes included in the fauna of the Albert shales of New Brunswick. These species are: *Rhadinichthys alberti* (Jackson), *Elonichthys browni* (*Jackson*), *E. elegantulus*, Eastman, *Canobius modulus* (Dawson), and a species of *Elonichthys* which I regard as new and which I have described on page 29 of this report and named after Dr. R. W. Ells.

DESCRIPTION OF SPECIES.

RHADINICHTHYS ALBERTI, (Jackson.)

Plate III, figs. 1-6.

Palæoniscus alberti, Jackson, 1851. Report on the Albert Coal Mine, etc., Boston, p. 22, plate I, fig. 1, plate II, figs. 2, 2 bis, 3, 4, 5, 8, and 6.

Palæoniscus cairnsii, Jackson, 1851. Ibid. plate I, fig. 3.

" *alberti*, Jackson, 1852. Description of five species of fossil fishes, Proc. Boston Soc. of Natural History. Vol. IV, p. 138.

Palæoniscus cairnsii, Jackson, 1852. Ibid. p. 139.

" *alberti and P. cairnsii*, Egerton, 1853. Quart. Jour. Geol. Soc., vol. 9, p. 115.

" *alberti*, Dawson, 1868. Acadian Geology, 2nd edition, p. 131, fig. 62.

Rhadinichthys alberti and R. cairnsii. Traquair, 1877, Quart. Jour. Geol. Soc., Vol. XXXIII, p. 559.

Palæoniscus alberti and P. cairnsii. Dawson, 1877. Canadian Naturalist, new series, vol. 8, pp. 338 and 339.

Palæoniscus alberti, Dawson, 1878. Acadian Geology, 3rd edition, p. 231, fig. 62; supplement (*P. alberti* and *P. cairnsii*,) p. 100.

Palæoniscus alberti and *P. cairnsii*, Newberry, 1889. Palæozoic Fishes of North America, Monographs U. S. Geol. Survey, vol. XVI, p. 187.

Rhadinichthys alberti, Smith Woodward, 1891. Cat. Fossil Fishes British Museum, part II, p. 465.

Rhadinichthys cairnsi, Smith Woodward, 1891. Ibid. p. 465.

" *alberti*, Eastman, 1908. Devonian Fishes of Iowa, Iowa Geol. Surv., vol. XVIII, p. 261.

Rhadinichthys cairnsi, Eastman, 1908. Ibid. p. 261.

This species is the first of the Albert mine fishes described by Jackson.

The original description of the species[1], as it appeared on page 22 of the "Report on the Albert Coal Mine," is as follows:—

"Pl. I, Fig. 1. This fish is the first one that was discovered by me at the Albert mine.

[1]As the Report on the Albert Coal Mine is not readily accessible to all, the original descriptions of Jackson's other named species (*Palæoniscus Brownii* and *Palæoniscus cairnsii*) will be quoted at length, in the following pages, where they apply.

"Description:—Fish, four diameters of its body long; head, obtuse or blunt, as if obliquely compressed on upper and front part; whole length, 3 3-10 inches; width, in middle of body, 85-100 inch; *fins*, one dorsal, opposite anal, small triangular, 3-10ths of an inch at base, jointed, drooping, as if the fish was dead before it was enclosed in the mud, (now shale). *Anal*, small, triangular, a little larger than dorsal; *Pectoral*, small, compressed into mass of scales of body of the fish; *Tail*, bifurcated, unequal, very long, and tapering in upper division, which extends to a fine point. The *scales* run down on upper division of tail, and become gradually smaller to tip; *caudal rays* come exclusively from under side of upper, and form lower division of tail. Scales of body brilliant, rhomboidal, wavy, serrated on posterior margins, colour light brown. This fish is embalmed and not petrified. No ridge of bone is seen to indicate the vertebral column, hence the bones must have been cartilaginous and compressible. The gill plates are too confusedly compressed to be dissected. I cannot find in any published book any figure of a fossil fish identical with this. It is evidently a Palæoniscus, and is probably a young individual, as seems to be indicated by its small size, and the delicacy of its scales. We will name it, provisionally, *Palæoniscus Alberti*, in commemoration of its being the first fossil fish discovered in Albert county, in New Brunswick."

Other specimens from the Albert mine, described by Jackson, but not named by him, are shown in his figures 2, 2 bis and 3 of plate II, and belong to this species. His figures 5 and 8 of the same plate represent specimens of *alberti* from the same locality, not mentioned in the text of his report. The original of figure 4, plate II, of which no mention is made in the text, has not been seen by the writer, but it probably also is of this species.

In the collections from the Albert shales of New Brunswick, belonging to the Geological Survey, this species is the one most abundantly represented. It evidently swarmed in countless numbers in the waters of its time.

A careful study of the type and figured specimens of Jackson's *Palæoniscus alberti*, and of the type of *P. cairnsi*, Jackson, has compelled the writer to believe that the latter is not specifically distinct from the former. A supposed difference in the ornamentation of the flank scales seems to have been relied on principally as a character denoting specific distinction.

Dr. Jackson's description of *Rhadinichthys cairnsi*, to be found on the same page of the 1851 report as that of *R. alberti*, is as follows:—

"Plate I, Fig. 3, represents a perfect fish of the genus Palæoniscus which was found on the 3rd of June last. In its general form and appearance it resembles the *Palæoniscus Elegans*, of Prof. Sedgewick, (Lond. Geol. Trans., 2d series, Vol. iii, Pl. 9, Fig. 1) and Agassiz, (Recherches sur les Poissons Fossiles, Vol. ii, Tab. 10, Fig. 5.) but it differs from that species in the striation of the scales, the striæ of the Hillsboro' species being parallel to the anterior and lower margins of the scales, and the shape of the scales differing essentially from Mr. Sedgewick's species.

"Description.—Fish, long and slender, 4 1-2 diameters of its body long; length of head, a little less than the largest diameter of the body; the head has the shape of an equilateral spherical triangle; tip of nose, or snout curiously tuberculated and dotted; gill plates cannot be dissected,

they are so brittle and confused with the head; *fins*, pectoral a little behind gill plates, and extend below the fish 3-10ths of an inch,—it is a narrow-pointed fin, well marked with its rays. *Dorsal fin* far back towards the tail, a little anterior to anal; it is half an inch long and 2-10ths of an inch high, and is well marked with its rays. *Anal fin* somewhat larger than dorsal, a little posterior to it. *Abdominal fin* very small, situated a very little in advance of the middle of the body; tail unequally bifurcated or heterocercal; *scales* run down on it becoming smaller and more and more acutely rhomboidal or lozenge shaped as they recede; caudal rays come exclusively from under side of upper division of tail. *Scales* obtusely rhomboidal on anterior and middle of body, and are distinctly striated parallel to anterior and lower margins, while they are smooth and very brilliant towards and upon the tail; dorsal scales large and in form of obtuse spherical triangles pointing backwards towards the dorsal fin. This species is not described in any book I have examined, and believing it to be new, I shall take the liberty of naming it *Palœoniscus Cairnsii*, after the highly intelligent superintendent of the Albert coal mine, William Cairns, to whose active and unremitting labours I am indebted for so many specimens of these interesting fossils."

Rhadinichthys alberti is of small size, rather slender, fusiform, averaging in length about 8·5 cm. Greatest depth of trunk in advance of the pelvic fins, slightly over one-fifth the total length. The head, in length, about equal to the maximum depth of the body. Eye of moderate size, placed far forward. Fins well developed. Dorsal fin beginning a little behind the mid-length of the fish, triangular, about the same size as, and arising somewhat in advance of the anal fin. Caudal fin much prolonged in upper lobe, deeply forked. Pectoral fins large, with a short base. Pelvic pair, if anything, nearer to the anal fin than to the pectorals, of small size. Teeth minute. Suspensorium oblique.

Anterior flank scales, plate III, fig. 5, about as deep as long (exposed surface), ornamented with striations, some of which are parallel to the lower and anterior margins; while others, fewer in number, have an oblique backward and downward direction and are confined to the upper, posterior quarter of the scale. These latter striations are deeper than the others, are comparatively short, and are most conspicuous toward the back margin. The former are fine, fairly regular, and occupy the remaining three-quarters of the scale surface, bending upward anteriorly parallel to the front margin. There are three or four of the coarser striæ and about six of the finer ones. The striations indent the posterior margin of the scales causing it to be minutely serrated. In the more posterior flank scales the striations are fewer in number and tend to disappear, the oblique striæ being still apparent when the remainder of the scale surface has become smooth. In these scales the serrations behind are reduced in number and are relatively coarser. In the body prolongation of the upper lobe of the tail the scales have the usual elongated diamond shape, with a surface in which a slight indication of a coarser longitudinal striation is still visible.

About ten to twelve enlarged ridge scales, (plate III, fig. 6,) occur in advance of the dorsal fin, reaching in a row forward to a point not far removed from the back of the head. They are considerably longer than broad, narrowly rounded in front, somewhat pointed behind, and are coarsely and irregularly striated longitudinally, the striations conforming in a general way

to the curve of the lateral margin. Enlarged scales also occur behind the dorsal fin and are continued back on the upper lobe of the tail, with a much increased overlap, to its termination. They diminish in size as they pass backward, and are much reduced in breadth, resembling large fulcra. In advance of the anal fin and between it and the caudal, a few enlarged scales, similar in shape and sculpture to those of the dorsal row, are also present. There appear to be three in advance of the anal fin and about the same number behind it. All the fin rays are jointed throughout, except the principal anterior ones of the pectoral pair, which appear to be entire proximally, and to be jointed only in their distal halves. They subdivide distally and have the appearance of being at times slightly striated in the direction of their length. Minute fulcra are present on the margin of the lower caudal lobe and on the anterior margins of the other fins. The head bones are ornamented with longitudinal ridges and tubercles, and transitions between the two. Figure 1 of plate III gives an attempted restoration of *Rhadinichthys alberti*, twice the natural size of the average specimen, based on the type material and the many specimens contained in the Geological Survey collections. Figures 2 and 3 of the same plate are reproductions of photographs of two individuals, collected by Dr. R. W. Ells, in 1907, from which a fair idea of the general proportions of the fish and the position of its fins can be obtained. The size of the restoration does not admit of a proper representation of most of the finer details of structure and ornamentation, such as the surface sculpture of the head-bones, the striation and serration of the scales, the articulation and subdivision of the fin rays, etc., so that these have been wholly or in part omitted. The ornamentation of the scales is given in the more enlarged figures 4, 5, and 6 of plate III. In the specimen reproduced in figure 3, plate III, the position and size of the maxilla, mandible, and eye are well suggested, but in the many specimens examined the bones of the head cannot be satisfactorily made out. In a number of examples the obliquity of the posterior outline of the opercular apparatus is clearly indicated.

The type specimen of *Rhadinichthys alberti*, No. 1960 of the Museum of Comparative Zoology, Cambridge, the original of Jackson's figure 1, plate I, is imperfect in many respects. The dorsal, anal, and caudal fins are but partially preserved, while the other fins, as well as the head, are missing. In most of the scales the finer details of ornamentation are obscure, and the posterior margins are broken. Although the scales are not, as a whole, well preserved, yet, some of them, well forward on the flank, on close examination, show that the same style of striation exists in them as in the type of *R. cairnsi*. The principal character apparently relied on, as a distinguishing one between this species and *R. cairnsi*, was the implied difference in the scale sculpture. Any difference in the ornamentation of the scales in these species, as throughout the Palæoniscidæ as a whole, may be expected to be most accentuated in the flank scales for some little distance back from the head. The scales of *R. alberti* were evidently regarded by Dr. Jackson as being smooth, as in the original description they are referred to as being "brilliant," no other reference being made to their ornamentation beyond the observation that the posterior margins are serrated. The scales of the type specimen of *R. cairnsi* are well preserved, with the sculpture particularly definite, plate III, fig. 4. In Jackson's description they are stated to be "distinctly striated parallel to anterior and lower margins," a description that, to be complete, needs some reference to the coarse, oblique striæ which are present in the upper back portion of the scale surface. To the writer the striation of the scales appears to be the same in both species, poorly preserved in the type of *R. alberti*, but very clearly shown in the type of

R. cairnsi, with a like serration of the posterior margin in both. Other characters distinguishing the two species are not observed, and the conclusion has been reached that there is no real distinction between the two. The type of *R. cairnsi* is rather larger than the average sized specimens of *R. alberti*. The striation parallel to the lower and front margins of the scales is seen in the majority of the many specimens in the Geological Survey collection of the general size of, and regarded as referable to, *R. alberti*, as well as in the two specimens shown by Jackson in figures 2 and 3 of plate I. These last were regarded by Jackson as belonging to one and the same species, but were not otherwise specifically determined. They are here referred to *R. alberti*. Three other specimens, figures 4, 5, and 8, of plate II, not alluded to in the text of Jackson's report, are evidently of this species. The originals of figures 4 and 5 consist of the posterior half of the fish only, consequently the anterior flank scales of these particular specimens have not been seen; they evidently, however, belong to *R. alberti*, reliance being placed on the characters displayed. The original of figure 8 includes scales some distance in advance of the dorsal and anal fins, in which the characteristic striation of *R. alberti* is revealed; its reference to this species is, therefore, considered proper.

Elonichthys browni (Jackson).

Plates IV, V, VI, VII, VIII, and IX.

Palæoniscus brownii, Jackson, 1851. Report on the Albert Coal Mine, etc., Boston, p. 22, plate I, figs. 2 and 5, plate II, fig. 1, and plate I, fig. 4.

Palæoniscus brownii, Jackson, 1852. Description of five new species of fossil fishes, Proc. Boston Soc. of Natural History, vol. IV, p. 138.

Elonichthys brownii, Traquair, 1877. Quart. Jour. Geol. Soc., vol. XXXIII, p. 553.

Palæoniscus (Elonichthys) *brownii* and *P. jacksonii*, Dawson, 1877. Canadian Naturalist, new series, vol. 8. p. 339.

Palæoniscus (*Elonichthys*) *brownii* and *P. jacksonii*, Dawson, 1878. Acadian Geology, 3rd edition, supplement, p. 101.

Palæoniscus brownii and *P. jacksonii*, Newberry, 1889. Palæozoic Fishes of North America, Monographs U. S. Geol. Surv., vol. XVI, p. 187.

Elonichthys browni, Smith Woodward, 1891. Cat. Fossil Fishes, British Museum, part II, p. 501, under doubtful and imperfectly defined species.

The type of this species, No. 1961, of the collection of the Museum of Comparative Zoology, Cambridge, Massachusetts, is from the Albert mines and was described by Dr. Jackson in 1851, in his "Report on the Albert Mine, etc.," and in the year following, in the Proceedings of the Boston Society of Natural History. It consists of the greater part of the fish, with the left side exposed, in an admirable state of preservation, and gives very minute details of structure. The specimen extends from close behind the head to a point some distance beyond the base of the tail, so as to include about one-third of the body prolongation of the upper lobe of the tail and the greater part of the lower lobe. The dorsal and anal fins are beautifully shown. From the anterior end of the base of the anal fin forward, the specimen is imperfect below, and the pelvic and pectoral fins are missing. The type specimen is well shown in Jackson's plate I, figure 2.

Over a dozen examples of a large fish from the shales of the Albert mines are now in the possession of this Survey, and are in the writer's opinion referable to this species. In fact, of the specimens of fossil fishes from this locality, all the large ones appear to belong to this species. They range in length from about 18·5 cm. (approximately of the size of the type specimen) to nearly 35·5 cm. or about 14 inches. The specimens depicted by Jackson in plate I, figure 5, and plate II, figure 1, are also believed to belong to this species. The original of Jackson's figure 4, plate I, the type of *Palæoniscus jacksoni*, Dawson, is not available for study, but, judging from the figure, it is presumably not distinct from *E. browni*. Its length, as stated by Dr. Jackson, was originally 15 inches.

Jackson's original description appeared as follows, on page 22 of his report: "Pl. I, Fig. 2. This beautiful fish was found by Mr. Brown, the captain of the mine, subsequent to my first visit to Hillsboro'. It is one of the largest, or full grown species. It was unfortunately broken in the operation of extracting, but it still is a very valuable specimen. This being the first fossil fish found by the chief miner, I have named it *Palæoniscus Brownii*.

"Description.—Fish nearly whole. It is one of the largest species yet found, and its length is three times the greatest width of its body; whole length, 5 3-10th inches; breadth, 1 7-10th inches; head broken off just in front of pectoral fin; extremity of tail broken; abdominal fin missing, it having been broken in getting out the specimen. Dorsal fin, a little behind middle of body, opposite, or rather a little in front of anal."

The original descriptions of the specimens shown in plate I, figure 4, and plate II, figure 1, are as under:—

"Pl. I., Fig. 4. This large and elegant fish was most unfortunately broken in splitting it out from the rock, only the posterior part of it having been saved in a fit condition for delineation. The whole length of the fish was originally fifteen inches. That portion which remains entire is 5 1-2 inches long; it was broken off through the posterior edge of the dorsal fin. It was an old fish, as is evident from the appearance of the scales which are thick, heavy, and have their striations in part obliterated, while the serrations are extremely sharp and deep. The scales are elongated rhomboids, and have many striæ upon their surface which run parallel with their upper and lower margins. Caudal scales, acute lozenges. They run down on upper division which is long and covered with scales. Rays of tail come off very distinctly, exclusively from under side of upper division, and the tail is unequal or heterocercal. Until we obtain an entire specimen, perhaps it will be prudent to abstain from giving a specific name. It is a species of the genus *Palæoniscus*.

"Pl. II., Fig. 1. This species so nearly resembles the *Palæoniscus decorus* of Sir Philip M. de Egerton, as on first view to pass for it; but on examining the lines of striæ, we are forced to regard it as another species. The four great dorsal scales, anterior to the dorsal fin, exactly resemble in form those represented in Sir Philip M. de Egerton's plate. (See Quarterly Journal Geological Society of London, for 1849.) The scales of one specimen* are striated, parallel with the superior and inferior margins, and are deeply and acutely serrated on their posterior edges.

*Evidently a misprint for *our*.

The lines of striation are worn away considerably, indicating, perhaps, that it was an old fish. It was, when entire, about eight inches long, and it is two inches in diameter from the anterior edges of the dorsal and anal fins. The lithographic delineation gives a sufficiently full exhibition of the character of this specimen, which appears to be of the same species, or very near the species, last described."

The type, and figured specimens of Jackson, together with the specimens belonging to this Survey, form a series from which it is now possible to form a fairly correct idea of the general shape of the species, and of many details of its structure.

Our knowledge of the head must, for the present, remain deficient, as in all the specimens that part is obscure, and provides the least reliable information, principally on account of the effects of crushing, which are more apparent here than in other parts of the body. Some of the specimens furnish an approximately true outline of the fish, with the exact position of the fins, but without much detail; from others we obtain particulars of structure, and the minutiæ of scale ornamentation.

From a study of all available material this species seems to possess stable characters in general, but to vary slightly as regards the ornamentation of the scales, a variation which appears to be quite independent of the age or size of the individual. It belongs to the genus *Elonichthys*.

Elonichthys browni (Jackson) may be described as follows:—

A species of moderately large size, reaching a length of 37·5 cm. (about 15 inches). Maximum depth of the trunk, slightly in advance of the pelvic fins, contained about three and three-quarters times in the total length. Length of head, including the opercular apparatus, about one-fifth of the total length. Fins rather large. Pectoral fin powerful, spreading, with a rather restricted base; rays articulated, except the first two or three proximally. Pelvic fins, small in comparison with the other fins, about midway between the pectoral and anal fins, in advance of the mid-length of the trunk. Anal fin, large, triangular, with a broad base, reaching posteriorly close to the tail. Dorsal fin, similar in shape to the anal but not quite so large, the centre of its base nearly above the anterior end of the base of the anal. Caudal fin large, the body prolongation of the upper lobe robust, extended, the lower lobe well developed. Fulcra in all the fins conspicuous. External bones of the head ornamented with definite ridges of varying length, straight or slightly tortuous and having a general longitudinal direction, replaced at times by tubercles. Flank scales, near the head, ornamented with numerous longitudinal striæ, and a serrated posterior border. Usually, in passing backward on the trunk, these striæ gradually disappear, being replaced by a few punctuations, the surface of the scales becoming smoother and the serrations of the posterior border fewer in number, until in the upper lobe of the tail both punctuations and serrations are lost and the scales are quite smooth. It is found, however, that the striations of the scales persist in a variable degree, in different specimens, in the posterior half of the trunk, and in some, even the caudal scales retain a number of the striæ. Enlarged, longitudinally striated, imbricating dorsal ridge scales extend in a row from near the head to the dorsal fin, and from the latter to the extremity of the tail, on the upper lobe of which they are of modified shape and gradually diminishing size. Between the anal

fin and the lower lobe of the tail a row of imbricating scales, enlarged and ornamented similiarly to those between the dorsal fin and upper lobe of the tail, also occur. Enlarged, longitudinally striated scales are seen in a number of specimens, between the anal and ventral fins, and between the latter and the pectorals, but whether these are disposed in a definite single row or not has not been ascertained. In all the fins the rays are articulated, and their joints, though generally smooth, are sometimes sculptured to a slight extent. This sculpture has been best observed in the dorsal and anal fins of the type specimen. In the more anterior part of the fins, it consists of a feeble oblique striation of the front margin of the joints, while more posteriorly their hind margins develop minute serrations.

In general proportions *E. browni* is moderately deep, the maximum depth of the trunk being contained about three and three-quarters times in the total length, of which the head occupies about one-fifth. The caudal pedicle is slender, its depth being about two-fifths of the greatest depth of the trunk. In side view, the dorsal outline, moderately flat in advance of the dorsal fin, descends rapidly near the head, which is rather short and obtusely pointed. The depth of the trunk is much diminished between the dorsal and anal fins, the line of the base of these fins being oblique to the longitudinal axis of the fish. The tail is deeply forked and the upper lobe considerably exceeds the lower one in length.

The mandibular suspensorium is apparently oblique. The teeth, as seen imperfectly in one specimen only, seem to be arranged in two rows, after the manner of the genus, viz., with small teeth in an outer row, and larger ones, at intervals, forming an inner row. In all the specimens the head is unsatisfactorily preserved, and no definite statement can be made regarding the shape and disposition of the bones.

In the fins, the rays are articulated throughout except the most proximal part of the first two or three rays of the pectoral. The dorsal fin, plate IV, fig. 2, is triangular, with a base nearly equal to the length of the anterior border. The posterior margin is straight or slightly concave and equals the base in length. As exhibited in the type specimen, plate I, fig. 2, and plate IV, fig. 1, the rays, anteriorly and proximally are 0·6 mm. broad, there being five rays in a space of 3 mm. The joints are about 1·5 mm. long, that is, their length is about three times their breadth, plate V, fig. 5. Proximally, the rays along the whole length of the base decrease but little, if at all, in thickness posteriorly The rays subdivide distally. They bear a longitudinal striation or groove, which begins near the base and is at first superficial. This groove deepens and becomes more decided near the mid-length of the fin, and culminates in a subdivision of the ray not far from the posterior margin of the fin. Distally a second, and apparently also a third subdivision, may take place. The joints retain very much the same length distally, as proximally, with the result that their length relative to their thickness is greatly increased with each successive subdivision, in other words, they become more slender. On the front border of many of the joints in the more anterior part of the fin, three or four slight, short striations are observed, directed upward and backward, obliquely to the longitudinal axis of the rays. These particular markings are not observed in the posterior half of the fin, where another style of ornamentation is developed, viz., a minute serration of the hinder border of the joints, the serrations also pointing upward and backward, plate V, fig. 6. The fulcra along the anterior

border form a conspicuous feature of the fin. Individually they are not quite straight, but have a slight sigmoid or double curve, and they taper to an obtuse point above. In the lower part of the fin, where they are most robust, their length is slightly over 1·5 mm., with a thickness of about 0·3 mm. at their lower ends; they do not decrease much in size in the fin's distal half.

The anal fin is larger than the dorsal one, and what has been said regarding the structure of the latter applies equally here. Its outline almost forms an equilateral triangle, with the base slightly less than the anterior height, and with the posterior margin regularly and moderately incurved. In one specimen in particular its proportions are well shown (figure 1, plate VI). In the type specimen, this fin, although admirably preserved with all details of ornamentation intact, does not exhibit the whole length of its base, as, posteriorly, there is a slight overlap of the lower border of the caudal pedicle due to distortion.

The pectoral fins are not well shown in most of the specimens seen. In one specimen, however, represented in figure 1, plate VIII, the left one of the pair is fairly well preserved, and from it we can judge of its proportions and relative size. In this specimen the fin is spread, naturally and without distortion it would seem, and an idea of power is conveyed by its outline. Its length, measured in a straight line from the base to the anterior distal end, is less than that of the dorsal fin in the same specimen. The anterior or outer border sweeps round in a graceful curve, and in this respect differs from the corresponding part of the dorsal and anal fins, which is more nearly straight. The base is short and is contained about four times in the fin's length. The inner margin is, in length, about equal to the base, but the posterior margin, when the fin is spread, as in the specimen, equals four-fifths the total length of the fin. The rays have about the same thickness as those of the dorsal and anal fins, and are similarly jointed and sculptured, with this difference, that, proximally the first few anterior rays remain unarticulated. The fulcra, continuous along the whole front border, do not differ from those of the fins already described.

The pelvic or ventral fins are relatively small, have a short base and seem to be long in proportion to their width. Their fulcra are well developed.

The caudal fin is preserved in a number of specimens in which its shape is clearly shown. It is deeply forked. The long, acuminate upper lobe is formed to the extent of about one-half its width by the body prolongation which reaches to its extreme tip. The lower lobe is shorter and is apparently more rounded in outline at its extremity, not coming to such an acute point behind. The fulcra of the lower lobe agree in size with those of the other fins. The fin rays spring from the whole length of the lower surface of the body prolongation, beginning anteriorly below at a point not far removed from the posterior termination of the base of the anal fin, and ending above at the distal extremity of the body prolongation. They are jointed and sculptured as in the dorsal and anal fins.

The scales are of moderate size, in the form of rhomboids on the flanks, with the usual peg-and-socket articulation, and with a considerable overlap. On the flank, half way between the dorsal fin and the head, their height, or breadth, is three-fourths of their length, plate V,

fig. 2. Nearer the head their height is relatively greater. In passing toward the tail their proportionate length gradually increases. Those about midway between the anal and dorsal fins are twice as long as high, and in the lobe of the tail the average proportion of length to height is 3 to 1.

The flank scales near the head are sculptured by striations, having a general longitudinal direction, and numbering from about sixteen to eighteen or twenty. Under a lens they have a decidedly rúgose appearance. These striations cover the whole of the exposed part of the scale, and extend forward in the over-lapped part to near the front margin, along which there is a narrow smooth border. Most of the striations are continuous through the length of the scale to its posterior margin, but a few are shorter and either merge into adjacent striæ or are interfered with by striæ oblique to their course. In the lower part of the scale the striations are generally parallel to the lower margin and curve up with it anteriorly. Those above assume a more or less oblique direction backward and downward. This difference in the direction of the striation in the upper and lower parts of the scale is accentuated in some of the scales, where, in the upper anterior half, the striæ are parallel to the diagonal connecting the upper back with the lower front angle of the scale, while those below the diagonal are parallel to the lower margin. The striæ are often more or less curved, resulting in slight variations in the general longitudinal direction. The posterior margin is indented by the striæ, the result being a conspicuous serration of that part, the number of serrations depending on the number of striæ at the back margin. In the type specimen, and in some others in the collection of the Geological Survey, the flank scales, as we pass backward toward the tail, gradually become smoother, the place of the striations, as they disappear, being taken by a diminishing number of punctations, plate V, fig. 3, but it is observed that the striations persist most near the anterior and posterior margins of the scales. As the height of the scale is reduced there is a corresponding reduction in the number of the posterior denticulations. When the tail is reached the scales have become almost smooth and there are few denticulations. In the body prolongation of the tail the scales are quite smooth, with entire margins. In some specimens in the collection, notably in the largest one obtained in the summer of 1908, there is a very general persistence of the striations throughout the length of the flank, even well on to the upper lobe of the tail. In different specimens there are observed various degrees of development of the longitudinal striæ of the scales in the more posterior portions of the flank, and although at first it was suspected that more than one species of *Elonichthys* was represented by the larger specimens from the Albert shales so far obtained, it is now believed that they all belong to the single species *E. browni*, a species having a scale ornamentation variable within limits.

From about twelve to fifteen enlarged, imbricating, dorsal ridge scales extend from a short distance back of the head to the dorsal fin. They are largest midway between the head and the fin, at the highest point of the back. As, in most of the specimens, these scales are badly crushed, and broken at the edges, it is difficult to obtain a clear outline of them, but the larger anterior ones appear to be ovate, slightly longer than broad, and to attain a breadth, in some of the specimens, of between 8 and 10 mm., not taking into account the transverse curve of the scale. On approaching the dorsal fin they are not so broad, and are more pointed behind. They are ornamented by wavy, frequently inosculating, longitudinal striæ somewhat coarser than

those of the anterior flank scales. The posterior margin is serrated. The four nearest the fin are well preserved in the specimen shown by Jackson in figure 1 of his second plate; of these one is shown in plate V, figure 4. As in the flank scales, a more posterior position leads to a replacement of the striæ by punctations, and an increasing area of smooth surface, in a variable degree in different specimens. The enlarged scales between the dorsal fin and the tail are similar in shape and ornamentation to those immediately preceding the dorsal fin, gradually decreasing in breadth and becoming more pointed behind, as well as more angularly convex transversely as they approach the tail, on the upper lobe of which they are continued in diminishing size to its upper extremity. An emargination of the overlapped anterior surface, present in the ridge scales preceding the dorsal fin, becomes more pronounced in those behind this fin, and especially so in those on the upper lobe of the caudal fin, which are V shaped. In these last the overlapped surface is much increased, and extends back to near the posterior end of the scale as a smooth, narrow, depressed area in which the preceding scale closely fits. There are three or four enlarged imbricating scales in a row between the anal fin and the lower lobe of the tail, and the same number between the former and the pelvic fins. These scales, in ornamentation and general shape, are similar to those of the dorsal ridge near the dorsal fin. In advance of the ventral fins enlarged scales are also present, with sculpture like that of the more anterior dorsal scales, but, as already mentioned, their exact disposition has not been ascertained, as none of the specimens seen provides sufficiently definite information in this respect. The lateral line scales on the flank extend in a row from near the head above the mid-height of the body backward toward the tail midway between the upper and lower surface of the caudal pedicle. Each of these scales is pierced by a small passage whose external opening has the form of a minute crescentic slit round which the surface of the scale is slightly tumid. In most of the specimens these scales are proportionately higher than those of the rows immediately above and below. In none of the specimens examined have the minute openings been traced as far as the tail.

Elonichthys browni (Jackson), from the Albert shales, differs from any known species of the genus. Its scale ornamentation resembles in a general way some of the species so admirably described and portrayed by Dr. Ramsay H. Traquair in his monograph on the Palæoniscidæ, in Vols. XXXI and LV of the Palæontographical Society of London; but differences in the general proportions of the body, in the proportions and relative size of the fins, in the exact style of sculpture of the scales and fin rays, as well as in other particulars, mark this Albert shales fish as a distinct species.

The type specimen of Dawson's *Palæoniscus jacksoni* (figured by Jackson in figure 4 of his first plate) is not available for study, but, judging from the figure, and from Dr. Jackson's remarks on its scale ornamentation, it appears to the writer probable that it is not distinct from *E. browni*. A specimen from McGill University museum, labelled *P. jacksoni*, Hillsborough, No. 2698, now before me, has the scale sculpture and the ornamentation of the joints of the fin rays such as are seen in Jackson's type (plate I, figure 2) with which it is evidently conspecific. Among the specimens from the Natural History Society of New Brunswick is the original of the one from which the plaster cast mentioned by Sir William Dawson in his "Acadian Geology" was taken, which cast formed part of the material on which *P. jacksoni* was based. The specimen consists of the posterior part of the fish, from slightly in advance of the dorsal fin

backward to the end of the tail. The anterior basal portion only of the anal fin is preserved, and the position of the dorsal fin is indicated, but the specimen is elongated by distortion, and both fins are more distant from the tail than they otherwise would be. The general contour of the specimen is much the same as that of others in the collections of the Geological Survey similarly distorted, and the characters of the scales are clearly those of *E. browni*, to which species the specimen is referred.

Elonichthys ellsi, Sp. nov.

Plate X, figs. 1–6.

A species of rather small size. Greatest depth a little less than one-fourth the length. Head, with opercular apparatus, one-fourth the total length. Dorsal fin large, arising very slightly behind the mid-length of the fish, and but little in advance of the anal fin, which is about the size of the dorsal. Both of these fins are triangular, with a base about equal to the length of the anterior border. Fulcra are apparently present on all the fins. They are seen plainly on the dorsal and anal fins. Of the ventral and pectoral fins, a few rays only are preserved, which serve as an index to the fins' position. Ventral fins rather closer to the anal than to the pectoral fins. The fin rays are articulated, except the principal ones of the pectoral fins, which are entire, at least, proximally; they are finely striated in the direction of their length, plate X, fig. 6. The tail is deeply forked. Scales of moderate size; about as deep as broad on the flank anteriorly, where they are ornamented with nine or ten conspicuous, narrow ridges, directed backward and deeply serrating the posterior border. Posterior flank scales less highly ornate, and with few, but well marked serrations on the posterior margin. Scales of the caudal body prolongation nearly smooth. Enlarged scales extend along the dorsal ridge in a row, in advance of the dorsal fin, to the head, and behind the same fin backward to the termination of the upper lobe of the tail. Similarly enlarged scales occur between the anal fin and the lower lobe of the tail, with a few, probably three or four, in front of the anal fin. Head-bones marked by irregular, short ridges, and tubercles. Suspensorium apparently oblique.

The ridges of enamel on the anterior flank scales, plate X, fig. 2, constitute the most conspicuous feature of the scale ornamentation of this species. These ridges, nine or ten in number, are mainly developed on the posterior half of the scale, and have a general direction backward and slightly downward, more rarely pointing horizontally backward in the upper portion of the scale, or even obliquely upward near the upper margin. When closely examined, the ridges are seen to be depressed at regular intervals, and thus have somewhat the appearance of rows of connected tubercules. In the anterior half of the scale they are represented only by 5 or 6 ill-defined ridges, having the same oblique direction. A few fine striæ occur near and parallel to the lower margin. The conspicuous serration of the posterior margin is due to the projecting ends of the enamel ridges. In the posterior flank scales, plate X, fig. 3, there are only three or four serrations in the back margin; the finer striations parallel to the lower margin persist, but in the upper part of the scale surface two or three oblique striations alone remain. The diamond shaped scales of the upper caudal lobe are generally marked by a longitudinal depression in their otherwise plane service.

The enlarged ridge scales are rugosely and irregularly striated longitudinally. Those behind the dorsal fin are the best preserved in the specimen, and are seen to be toothed behind, plate X, fig. 4. They have an elongated oval outline, and undergo a modification in shape on the upper margin of the tail similar to that observed in the species of *Elonichthys* and *Rhadinichthys* already described. Conspicuous, horizontal striations or linear depressions occur in these modified scales of the caudal ridge, plate X, fig. 5.

The most distinctive character of the species is the style of ornamentation of the anterior flank scales, which is different from that of any other of the Albert shales fishes, and, so far as the writer is aware, from that of any species of the Palæoniscidæ.

The species is named after Dr. R. W. Ells, to whom we are indebted for the one and only specimen known. This specimen constitutes the type of the species.

Figure 1, plate XI, gives a fairly good representation of the type specimen twice the natural size.

Elonichthys elegantulus, Eastman.

Elonichthys elegantulus, Eastman, 1908. Devonian Fishes of Iowa, Iowa Geol. Surv., vol. XVIII, p. 274.

Of this species Dr. Eastman, in the above report, writes as follows:—

"A study of an extensive suite of material from the lower Carboniferous of Albert county, New Brunswick, including the originals of Dr. C. T. Jackson's figures and descriptions, shows that a minute form, apparently closely allied to the Scottish *E. striatulus*, is present in this horizon and locality, where it accompanies *E. browni* and the several species of Rhadinichthys already noticed in the preceding pages. The new form, for which the title *E. elegantulus* is not inappropriate, may be readily distinguished by its small size, slender and graceful proportions, and decidedly prominent, even coarse details of scale ornament. The scales are traversed longitudinally by a number of closely crowded raised ridges, smooth, continuous, glistening, and the whole presenting an appearance not distantly recalling Ptycholepis, from a much later horizon. In addition, the lateral line is very conspicuous. The head and fin structures are not clearly revealed in any individual that has thus far come to light, but the general resemblance to the little fish made known by Traquair from Eskdale and East Lothian necessitates its reference to the same vicinity."

This, the smallest, and, with *R. alberti*, the most abundantly preserved of the fishes at the Albert mines, is readily recognized by its rugose scale markings. Its small size, in conjunction with its generally imperfect state of preservation, leads one to suspect that it may be the young of one of the species already known from this locality, possibly of *R. alberti*. Of the many scores of specimens in our collections nearly all lack proper definition of outline, and the head is, as a rule, very imperfectly preserved. Its principal characters, however, may be stated to be as follows: In general outline resembling *R. alberti*, but much smaller. Length averaging about 46 mm., or about half the length of *R. alberti*; considerably shorter than *Canobius modulus*

and not so stout as that species. The proportion of depth to length about as 1 to $3\frac{3}{4}$. Dorsal fin opposite or arising slightly in advance of the anal fin. Enlarged, longitudinally striated scales occur in a row on the back throughout its length on to the tail, and ventrally, behind and in advance of the anal fin. The head bones are longitudinally and irregularly striated. The anterior flank scales have generally two or three conspicuously, slightly oblique, longitudinal ridges in the upper portion of their exposed surface, with about two less conspicuous ones beneath them, having more the appearance of striations than ridges. These latter are parallel to the lower scale margin and show a disposition to curve upward in front parallel to the anterior margin. Posterior margin with four or five decided serrations. The posterior flank scales retain the coarse ornamentation, with a reduction in the number of ridges and serrations. In these a few fine striations can be detected parallel to the lower margin. The lateral line is conspicuous and appears to the unaided eye as a raised line traversing the length of the flank at mid-height.

The generic position of this small form appears to the writer to be problematical.

Canobius modulus (Dawson).

Plate XI, figs. 1–7.

Palæoniscus (*Rhadinichthys*) *modulus*, Dawson, 1877. Canadian Naturalist, new series, vol. VIII, p. 338, figs. a–d; and 1878, Acadian Geology, 3rd edition, supplement, p. 98, figs. 18 a–d.

Palæoniscus modulus, Newberry, 1889. Palæozoic Fishes of North America, Monographs U. S. Geol. Survey, vol. XVI, p. 187.

Rhadinichthys modulus, Smith Woodward, 1891. Cat. Fossil Fishes, British Museum, Part II, p. 466.

Rhadinichthys modulus, Eastman, 1908. Devonian Fishes of Iowa, Iowa Geol. Survey, vol. XVIII, p. 262, fig. 39.

This species was first described by Sir William Dawson in 1878 (Canadian Naturalist), from specimens obtained from Beliveau, N.B., and Horton, N.S. Three specimens from the Peter Redpath museum, Montreal, have been examined by me. These are, the type collected by Dr. Frank Adams at Beliveau, plate XI, fig. 2, with a less perfectly preserved specimen on the same piece of shale, and a third specimen, plate XI, fig. 3, from Horton, from which the figure accompanying Dawson's description was evidently principally prepared.

This fish is short and robust, the mandibular suspensorium is apparently nearly vertical, the head is blunt in front, and a row of enlarged ridge scales passes backward from the occiput to the dorsal fin, and occurs again in advance of the caudal fin. Similarly enlarged scales are present in a single row along the belly. These characters suggest its being referable to Traquair's genus *Canobius* rather than to *Rhadinichthys*, to which genus it was assigned when first described.

The three above-mentioned specimens supply the following information regarding the structural characteristics of the species:—

The fish is small, robust, in general shape fusiform, reaching a length of 59 mm. with a depth in advance of the dorsal fin of 15 mm. The length of the head, including the opercular apparatus, is a little less than one-fourth of the total length. The snout is rounded and projects beyond the lower jaw. The orbit is large and placed far forward. The bones of the head are ornamented with well defined, short vermicular ridges, and tubercles, the former being generally in the direction of the length of the bone. The mandibular suspensorium is nearly vertical, and thus differs from that of *Rhadinichthys*, which is oblique. The dorsal and ventral fins are triangular and of fair size, the former slightly larger than the latter. In the ventral fin the base is about equal to the anterior and posterior margin. In the dorsal fin the base is proportionately larger and exceeds the posterior height. The dermal rays are delicate and seem to bifurcate distally; they are articulated, with the exception of the principal ones of the pectoral fins, which apparently are not articulated, at least proximally. Fulcra occur on all the fins. The anal fin is opposite the dorsal, and the ventral pair is slightly closer to the anal than to the pectorals. The caudal fin is heterocercal and deeply forked, the body prolongation in the upper lobe tapering gradually. The scales are rather coarsely sculptured. The exposed surface of those on the flank, anteriorly, plate XI, fig. 4, is slightly higher than broad, but a little farther back the height and breadth are about equal. Their sculpture consists of two or three delicate but distinct well-defined ridges in the lower half of the surface, parallel to the lower margin, with three to five short, prominent ridges in the upper half of the scale; these latter are directed obliquely backward and downward in a somewhat divergent manner, from a slightly raised but ill-defined area confined to the upper, anterior portion of the scale. These short ridges do not, as a rule, reach the posterior margin, and often stop far short of it. The posterior edges of the flank scales are coarsely toothed, three or four being the usual number of the denticulations. In passing backward the surface ridges of the scales are reduced in number, as are also the denticulations of the posterior margins, plate XI, fig. 6, until posteriorly, in the small diamond-shaped scales of the caudal body prolongation, all trace of sculpture is lost and the surface of each scale is smooth. Enlarged, imbricating scales, plate XI, fig. 7, extend along the median line of the back, in a single row, from the head to the commencement of the dorsal fin, and from behind this fin to the caudal one, on which they are continued as large fulcra-like modifications, decreasing in size posteriorly. Their sculpture consists of well-marked longitudinal ridges, conforming, in a general way, to the curvature of the lateral margins. On the ventral surface a row of similarly enlarged and ornamented scales occurs between the ventral and anal fins, and between the latter and the base of the caudal, where it gives place to small fulcra on the lower anterior margin of the tail. Similarly enlarged scales appear to be present in advance of the ventral fins as far forward as the pectoral pair, but they are imperfectly seen and nothing definite can be said regarding them. The enlarged dorsal scales are ovoid in outline, broadly rounded in front, and slightly narrower behind. They decrease in size toward the head, the largest ones occurring in advance of the dorsal fin. The ventral ridge scales nearest to the base of the tail are particularly conspicuous. Of the flank scales the largest are those of the lateral line. Toward the back and belly the flank scales decrease in size, those of three or four rows on either side of the median dorsal row being decidedly smaller, plate XI, fig. 5, with a more sloping posterior border,

and with only prominent downwardly oblique ridges composing the sculpture; the scales on either side of the median ventral line are similar to these small ones in size and sculpture.

Canobius modulus has about the same length as *C. ramsayi*, Traquair, but is not so deep. The scales are differently sculptured, and in this respect the species is distinct from all other described ones of the genus. The specimen from Horton, N.S., is slightly smaller than the type specimen from Beliveau, N.B.

Measurements.

	MM.
Length of type specimen, plate XI, fig. 2	59
Depth in advance of dorsal fin	15
Length of head, including opercular apparatus	13
Flank scales, exposed surface, vertically, four in a space of	4·5
Flank scales, exposed surface, longitudinally, four in a space of	3·75
Length of specimen from Horton, plate XI, fig. 3	55
Depth midway between pectoral and anal fins	14
Depth in front of dorsal fin	12·5
Dorsal ridge scales, in advance of dorsal fin, three in a space of	5·5

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PLATE I.

PLATE I.

Reproduced from a photograph of Dr. Jackson's original Plate I, illustrating the descriptions of fossil fishes in his "Report on the Albert Mine, etc.," 1851.

Fig. 1. *Palæoniscus alberti*, Jackson. Type of the species. The original is in the Museum of Comparative Zoology, Cambridge, No. 1960. It shows the left side, is imperfect anteriorly, and lacks the pectoral and ventral fins.

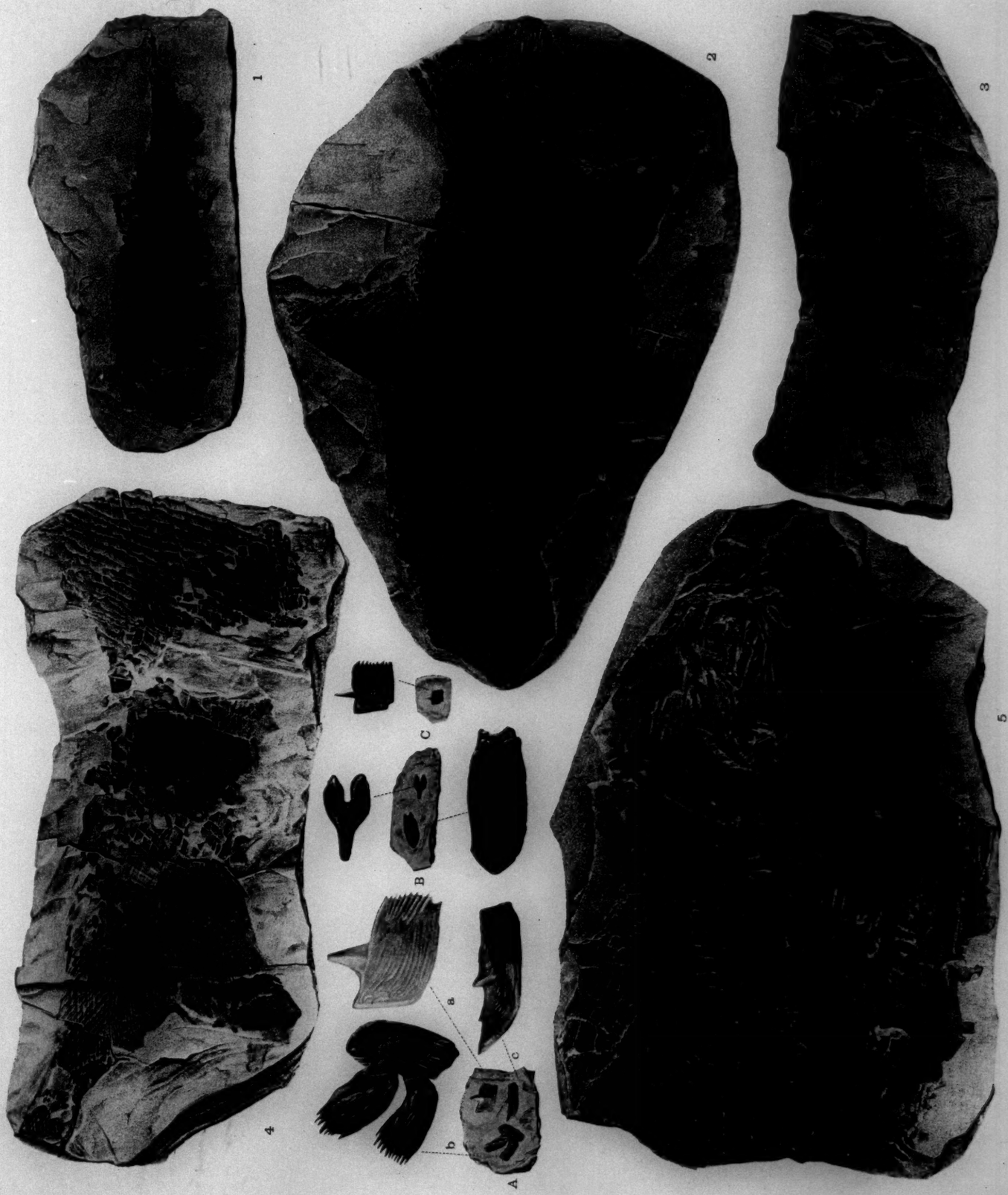
Fig. 2. *Palæoniscus browni*, Jackson. Type of the species. Original in the Museum of Comparative Zoology, Cambridge, No. 1961. A well preserved specimen, presenting the left side. The head, the lower surface in advance of the anal fin, and the extremity of the tail are missing.

Fig. 3. *Palæoniscus cairnsi*, Jackson. Type of the species. Original in the Museum of Comparative Zoology, Cambridge, No. 1956. The entire length of the fish, right side. Pectoral and ventral fins showing, in part, dorsal and anal fins better preserved.

Fig. 4. Referred to by Dr. Jackson as *Palæoniscus* sp. Type of *P. jacksoni*, Dawson. The hinder portion of a large fish, right side, from the neighbourhood of the dorsal fin backward including the tail. This specimen is apparently lost.

Fig. 5. Specimen in the Museum of Comparative Zoology, Cambridge, consisting of the anterior half of the fish, right side. No. 1957. No fins preserved. Not mentioned in Jackson's report.

Figs. A, B, and C. Represent separate scales, of the natural size, and also enlarged about four times. These particular scales are not mentioned by Jackson, and the specimens themselves have not been found.



HELIOTYPE CO., BOSTON.

PLATE II.

PLATE II.

Reproduced from a photograph of Dr. Jackson's original Plate II, illustrating the descriptions of fossil fishes in his "Report on the Albert Mine, etc.," 1851.

Fig. 1. In his reference to this specimen Jackson expresses the opinion that it "appears to be of the same species, or very near the species" represented in plate I, figure IV. It consists of the left side of the fish from a little in advance of the dorsal and ventral fins backward to include the anal fin. The original belongs to the Boston Society of Natural History, No. 7902.

Fig. 2, 2 bis. Referred to by Jackson as a small species of Palæoniscus. The original of figure 2 is in the Museum of Comparative Zoology, Cambridge, No. 1959. Figure 2 bis shows the imprint of the same. The fish has been flattened vertically and presents a dorso-lateral view. The left pectoral, and anal fins are preserved.

Fig. 3. Dr. Jackson expresses the opinion that the original of this figure belongs to the same species as the fish represented in figure 2, 2 bis. The specimen is the property of the Museum of Comparative Zoology, Cambridge, No. 1958, and is also flattened so as to show the back.

Fig. 4. Although figured, this specimen is not mentioned in Jackson's descriptions. Its whereabouts is not known. The figure shows the posterior half of a fish, left lateral aspect.

Fig. 5. Not mentioned by Jackson. The original is in the museum of the Boston Society of Natural History, No. 7898. It also consists of the hinder half of a fish, left side. The dorsal, anal, and caudal fins are well preserved.

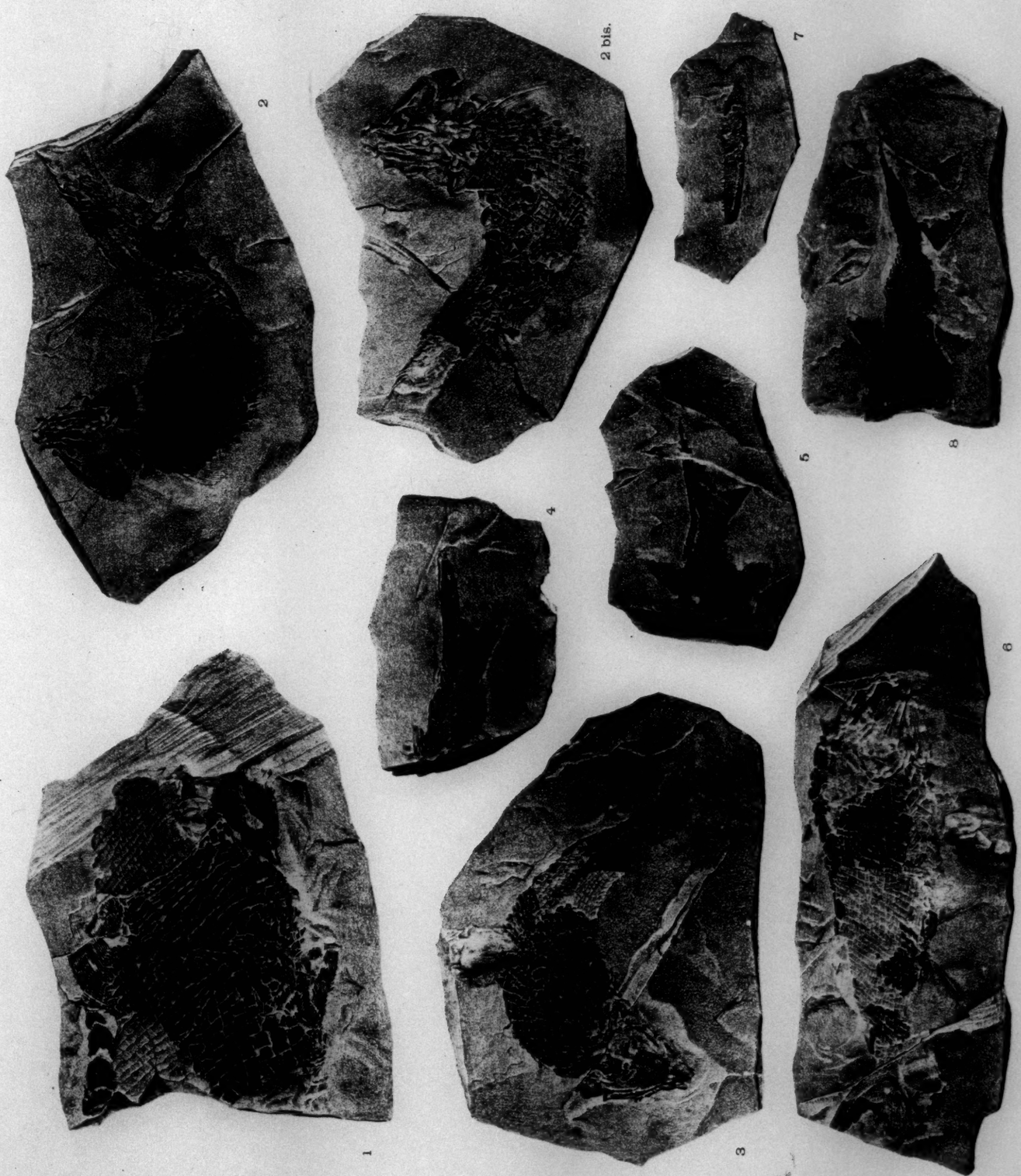
Fig. 6. Wrongly referred to in Jackson's description (p. 24) as figure 8. The specimen is apparently lost. The full length of the fish was preserved.

Fig. 7. Lower jaw of a Palæoniscus, the property of the Museum of Comparative Zoology, Cambridge. No. 1953.

Plate II, figure 8. This specimen, not referred to in Jackson's report, is in the possession of the Boston Society of Natural History, No. 7898A. Slightly more than half the fish is seen, from about the position of the ventral fins to the extremity of the tail. The dorsal and anal fins are shown.

GEOLOGICAL SURVEY, CANADA.

PLATE II.



HELIOTYPE CO., BOSTON.

PLATE III.

PLATE III.

Fig. 1. *Rhadinichthys alberti* (Jackson), restored outline; twice the natural size. Page 18.

Fig. 2. *Rhadinichthys alberti*, an average sized specimen in which the dorsal, anal, and caudal fins are well preserved; reproduced from a photograph. Natural size.

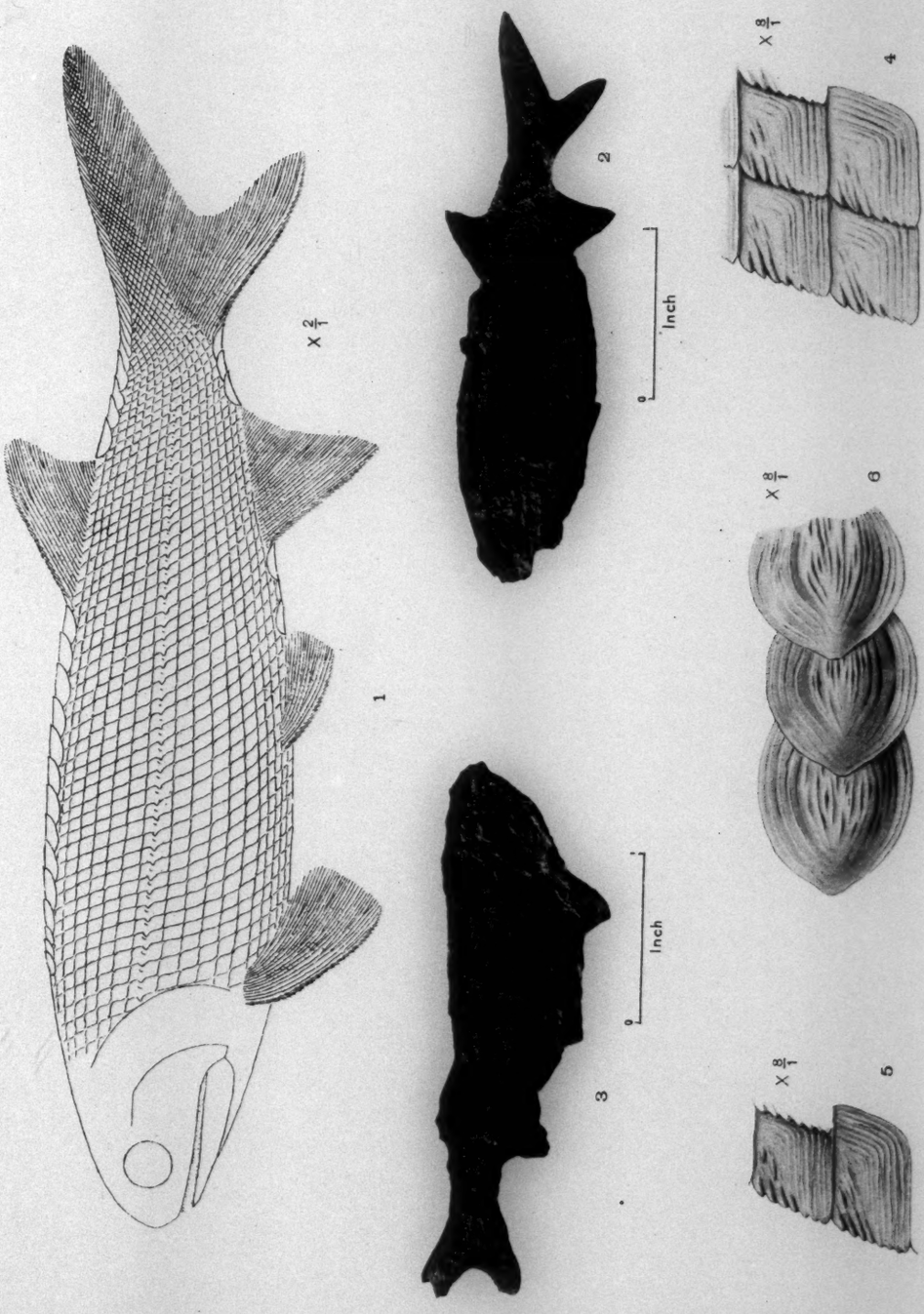
Fig. 3. *Rhadinichthys alberti*, a second specimen, showing the position and size of the eye, and pectoral and anal fins; from a photograph. Natural size.

Fig. 4. *Rhadinichthys alberti*, anterior flank scales from the type of *R. cairnsi;* eight times the natural size.

Fig. 5. *Rhadinichthys alberti*, anterior flank scales from the original of figure 3, plate II; similarly enlarged.

Fig. 6. *Rhadinichthys alberti*, dorsal ridge scales, about midway in the series in advance of the dorsal fin, from the original of figure 3, plate II; also enlarged eight times.

In this plate, and in those following, all the figures, other than those reproduced from photographs, are from drawings made by the author.



L.M.LAMBE, Delt.

HELIOTYPE CO., BOSTON.

PLATE IV.

PLATE IV.

Fig. 1. *Elonichthys browni* (Jackson), photographic reproduction of the type of the species, figured by Jackson in his first plate. In this beautifully preserved specimen the rays of the dorsal and anal fins, as well as the ornamentation of the scales, are particularly well shown. Natural size. Page 22.

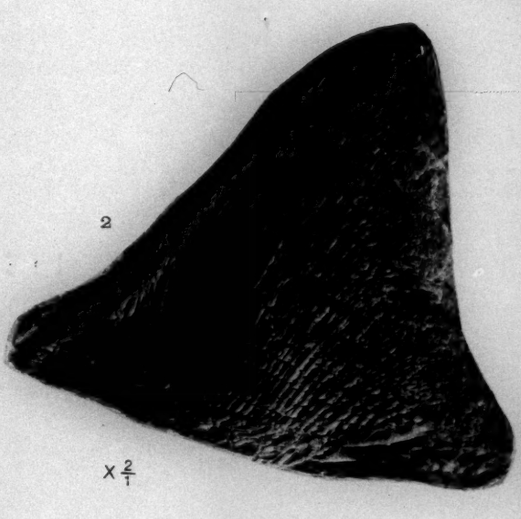
Fig. 2. *Elonichthys browni*, the dorsal fin of the above, reproduced from a photograph; twice the natural size.

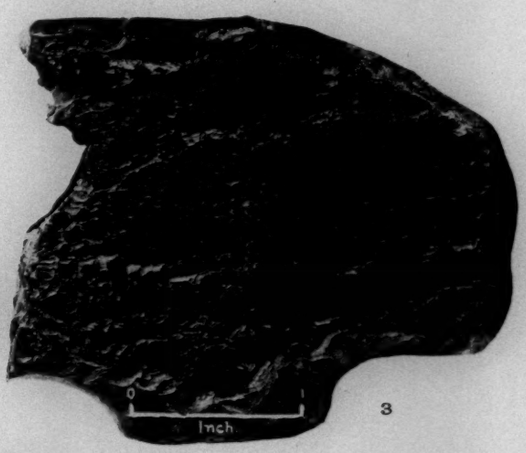
Fig. 3. *Elonichthys browni*, photographic reproduction of the original of Jackson's figure 1, plate II. This specimen is of special interest as in it the posterior four of the enlarged ridge scales in advance of the dorsal fin are preserved, as well as the left ventral fin. Natural size.

Fig. 4. *Elonichthys browni*, the original of Jackson's figure 5, plate I, with the ornamentation of the scales in good condition; from a photograph. Natural size.

GEOLOGICAL SURVEY, CANADA.

PLATE IV.





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HELIOTYPE CO., BOSTON.

PLATE V.

PLATE V.

Fig. 1. *Elonichthys browni* (Jackson), restoration in which the ornamentation of the scales, etc., is omitted. Natural size. Page 24.

Fig. 2. *Elonichthys browni*, flank scales, from two rows next above the lateral line, midway between the head and the dorsal fin, in the type specimen; six times the natural size.

Fig. 3. *Elonichthys browni*, flank scales next above those of the lateral line, beneath the front end of the dorsal fin in the type specimen; six times the natural size.

Fig. 4. *Elonichthys browni*, ridge scale, second in advance of the dorsal fin, in specimen No. 7902, the original of figure 1, plate II; four times the natural size.

Fig. 5. *Elonichthys browni*, rays and fulcra of the dorsal fin of the type specimen, from the upper part of the proximal half of the fin; six times the natural size.
At *a* a fulcrum is shown directly supported by, and forming the distal end of one of the rays.

Fig. 6. *Elonichthys browni*, rays from close to the middle of the base of the dorsal fin of the type specimen; six times the natural size.

GEOLOGICAL SURVEY, CANADA.

PLATE V.

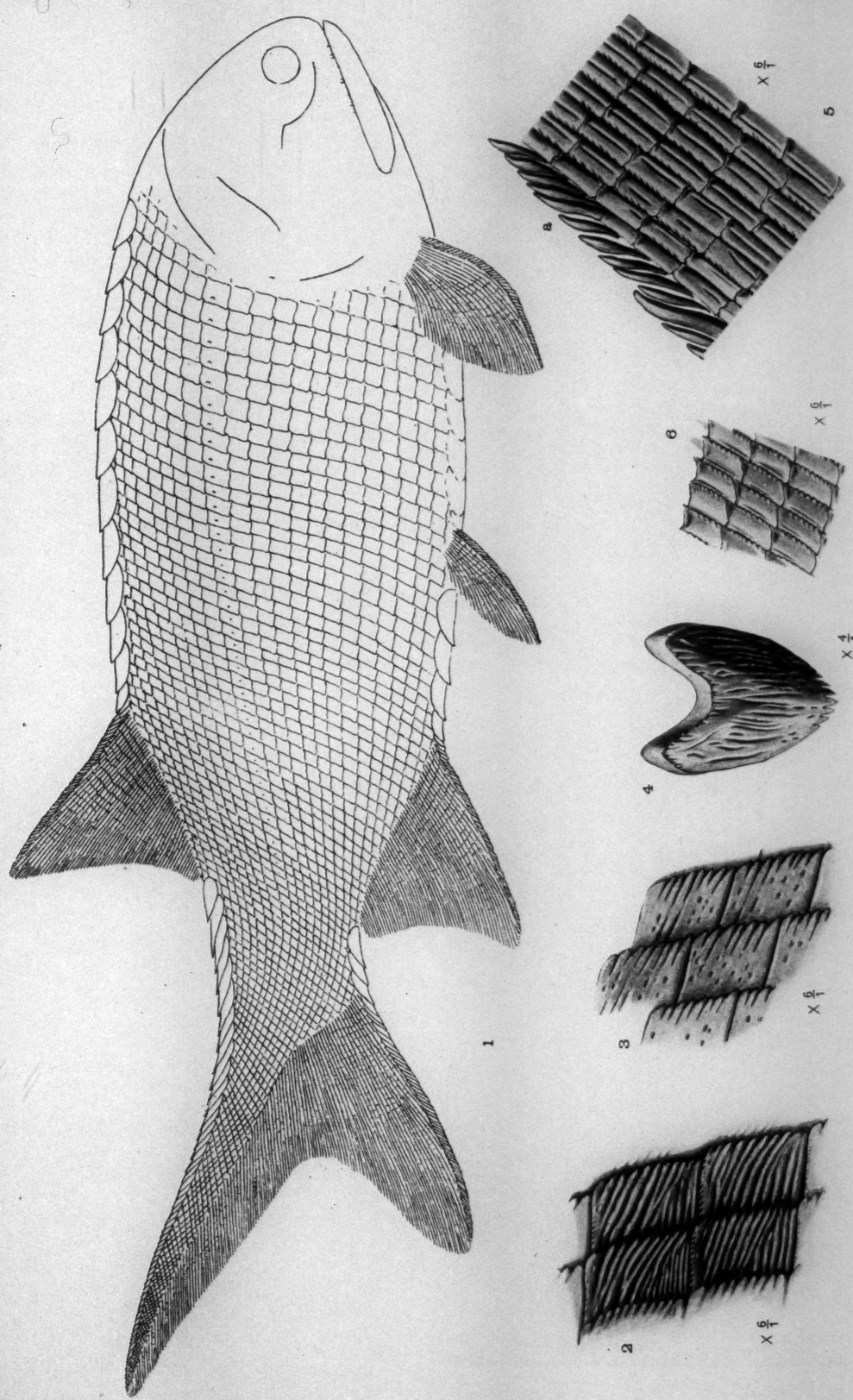

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PLATE VI.

PLATE VI.

Fig. 1. *Elonichthys browni*, a specimen, collected by the writer in 1908, in which the size and position of the dorsal, caudal, and anal fins, as well as the general contour of the fish, are well shown; from a photograph. Natural size. Locality—Frederick brook, Albert mines. Page 26.

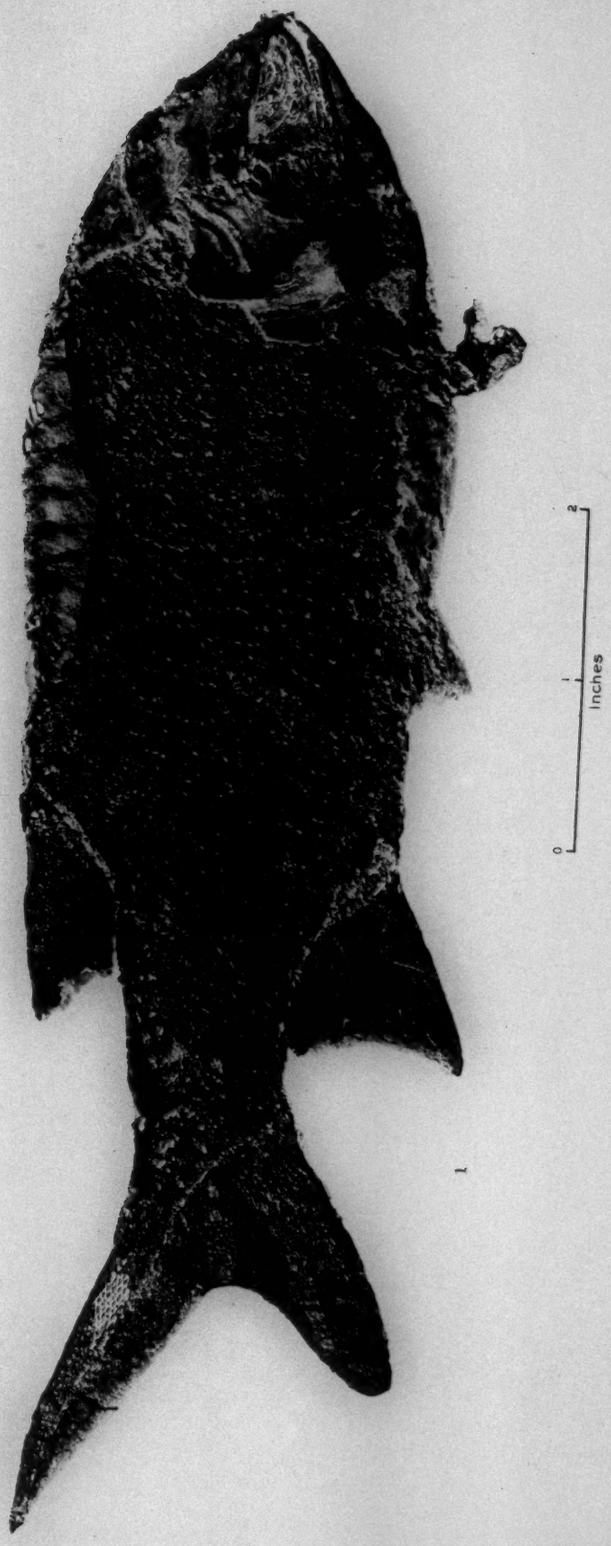

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PLATE VII.

PLATE VII.

Fig. 1. *Elonichthys browni*, a specimen showing all the fins, and the enlarged scales in advance of and behind the dorsal and anal fins; from a photograph. Natural size. Obtained by James Robertson, in 1907, from an exposure on Frederick brook, Albert mines.

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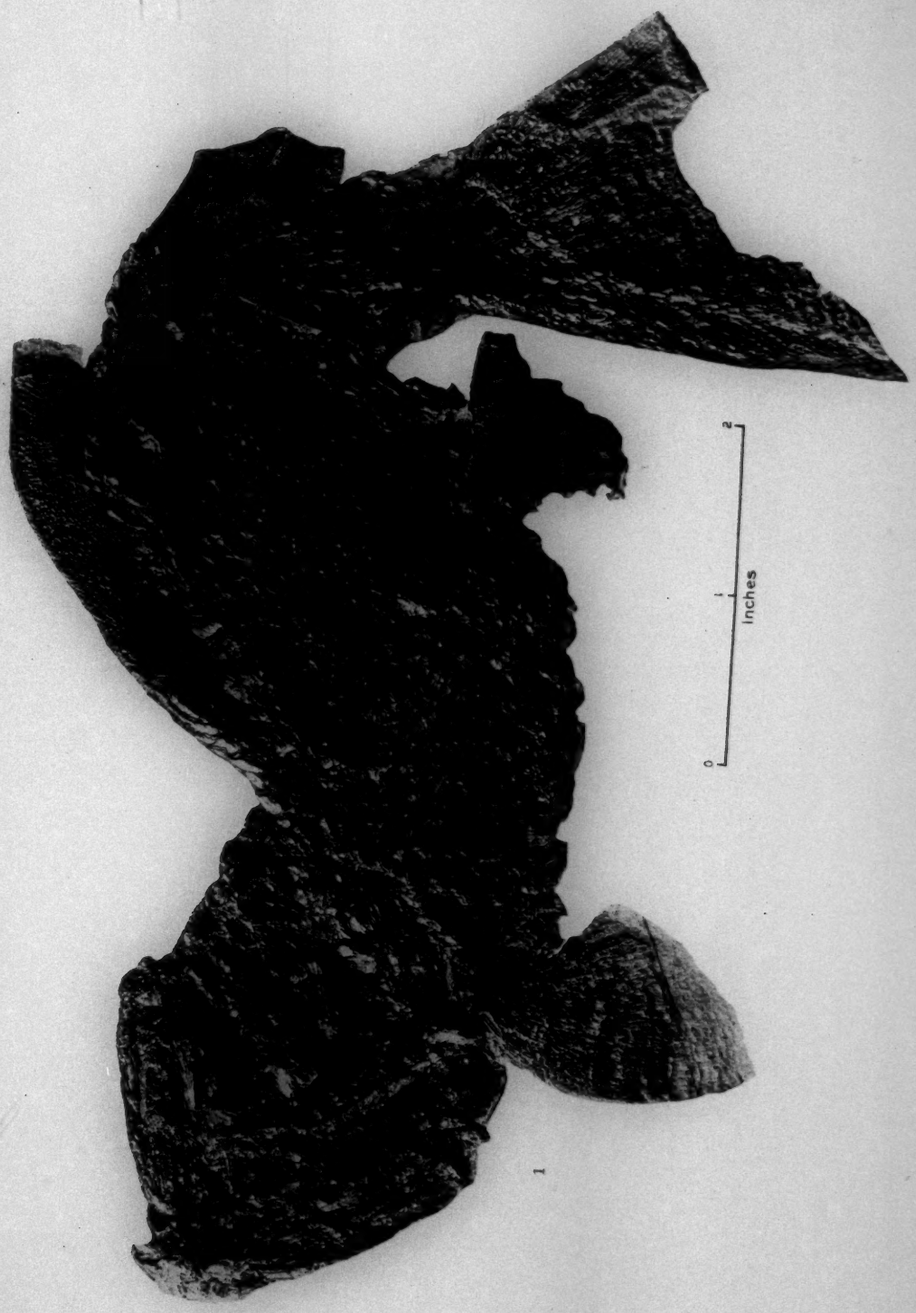
PLATE VIII.

PLATE VIII.

Fig. 1. *Elonichthys browni*, a large specimen reproduced here principally for the sake of the pectoral fin and the tail, which are well shown; from a photograph. Natural size. Frederick brook, Albert mines, collection of 1907, James Robertson. Page 26.

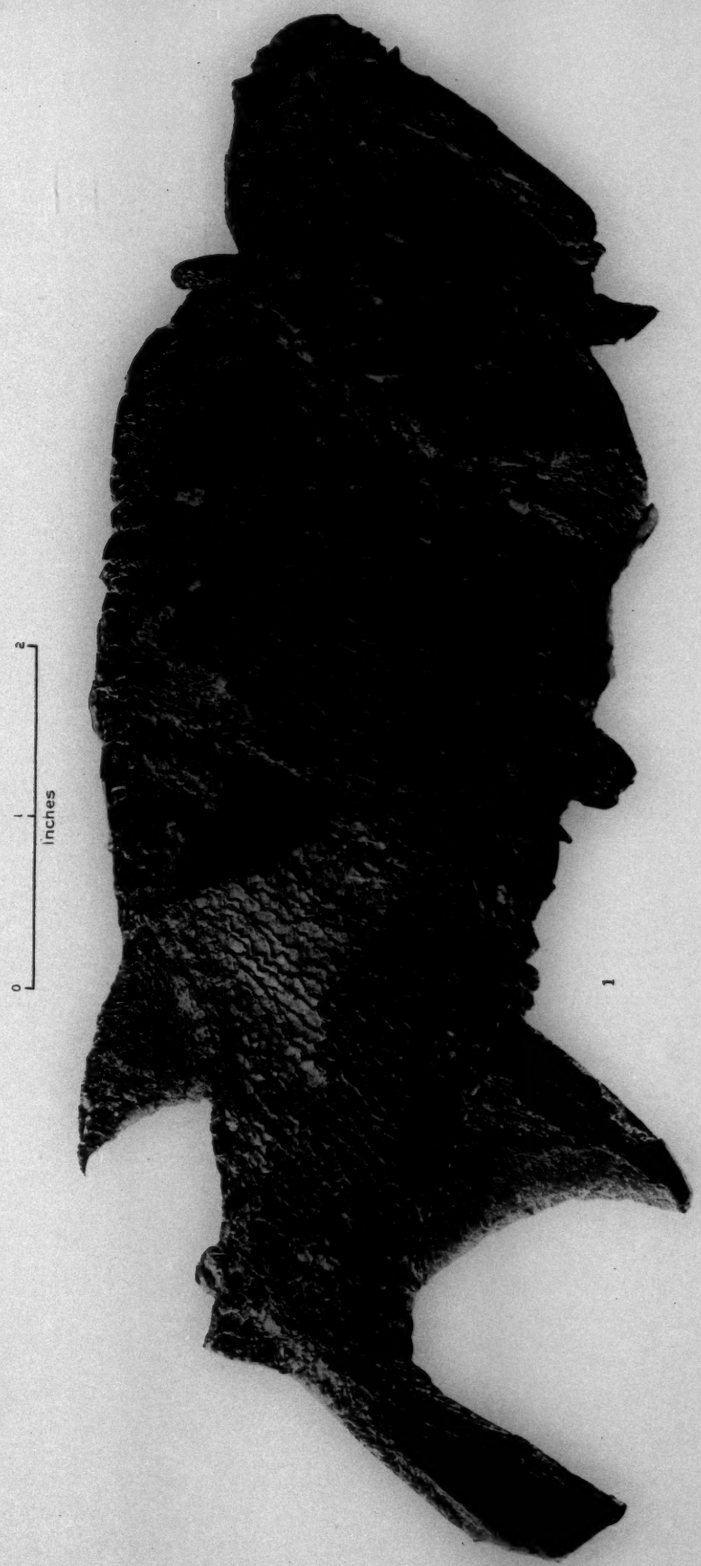


HELIOTYPE CO., BOSTON.

PLATE IX.

PLATE IX.

Fig. 1. *Elonichthys browni,* photographic reproduction of a specimen, of large size, to show the dorsal ridge scales and the position of the dorsal and anal fins. Natural size. Frederick brook, Albert mines, collection of 1908, Lawrence M. Lambe.



MELIOTYPE CO., BOSTON.

PLATE X.

PLATE X.

Fig. 1. *Elonichthys ellsi*, Lambe, type, and only known specimen, obtained by R. W. Ells at the Albert mines in 1876; from a photograph. One and one-half times the natural size. Page 29.

Fig. 2. *Elonichthys ellsi*, anterior flank scales; eight times the natural size.

Fig. 3. *Elonichthys ellsi*, posterior flank scales, from slightly above the mid-height of the body in line with the back part of the dorsal fin; similarly enlarged.

Fig. 4. *Elonichthys ellsi*, the second (part of) and third dorsal ridge scales from behind the dorsal fin; similarly enlarged.

Fig. 5. *Elonichthys ellsi*, the seventh, eighth, and ninth dorsal ridge scales, from behind the dorsal fin, viewed from the side. The fifth of these scales is the first of the series on the body prolongation of the caudal fin. Six times the natural size.

Fig. 6. *Elonichthys ellsi*, fin rays from the anterior part of the dorsal fin near its base; six times the natural size.

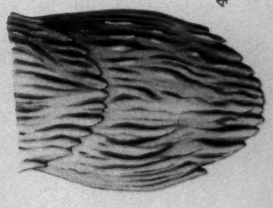
GEOLOGICAL SURVEY, CANADA.

PLATE X.

1 X1 1/2

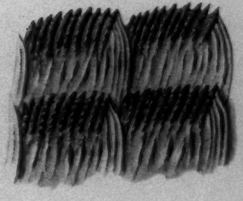
6 X 6/1

5 X 6/1



4 X 8/1

3 X 8/1



2 X 8/1

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PLATE XI.

PLATE XI.

Fig. 1. *Canobius modulus* (Dawson), restored outline with the striation and serration of the scales left out; twice the natural size. Page 31.

Fig. 2. *Canobius modulus*, type specimen, twice the natural size, from a photograph. In this specimen, obtained by Frank D. Adams, at Beliveau, N.B., the orbit is conspicuous, the tail is very distinct, and the scale ornamentation throughout well shown, but the dorsal ridge scales are not in view. Twice the natural size.

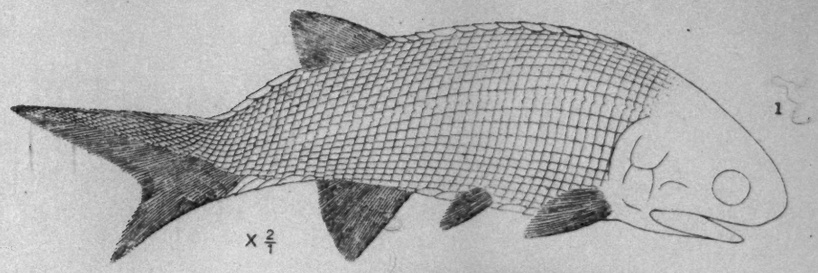
Fig. 3. *Canobius modulus*, a specimen from Horton, N.S., showing the number and shape of the dorsal ridge scales; from a photograph. Twice the natural size.

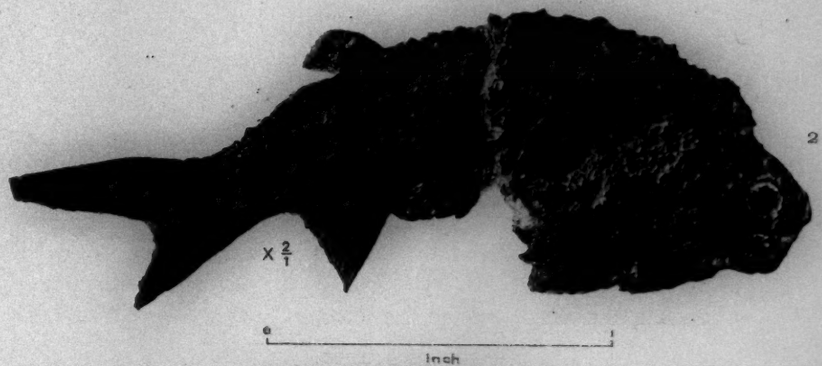
Fig. 4. *Canobius modulus*, anterior flank scales, from the two rows beneath the lateral line scales, in the type specimen from Beliveau, N.B.; twelve times the natural size.

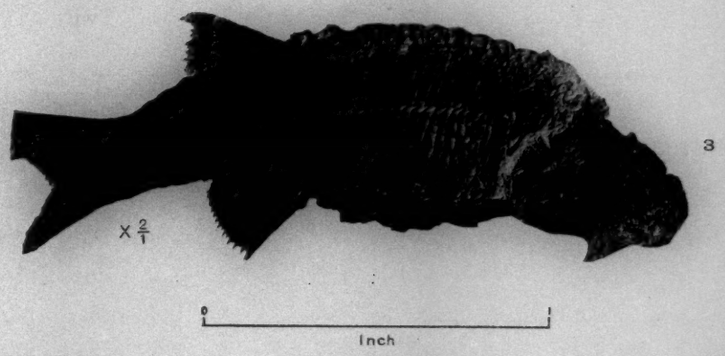
Fig. 5. *Canobius modulus*, anterior dorsal scales, next to the enlarged ones of the dorsal ridge, from the type; twelve times the natural size.

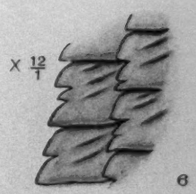
Fig. 6. *Canobius modulus*, posterior flank scales, beneath those of the lateral line, in the type specimen; enlarged twelve times.

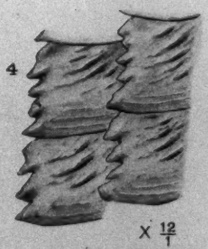
Fig. 7. *Canobius modulus*, dorsal ridge scales, about half-way between the head and the dorsal fin, in the specimen from Horton, N.S. Similarly enlarged.

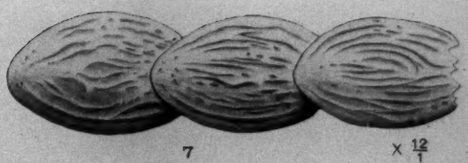












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